U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE TG 230A

SHORT-TERM CHEMICAL EXPOSURE GUIDELINES FOR DEPLOYED MILITARY PERSONNEL

May 1999 Version

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A multi-disciplinary workgroup participated in assembling this technical guide:

Project Manager:	**Veronique Hauschild**
Key Technical Authors and Technical Contributors to TG 230A:	**Mark S. Johnson, Ph.D** **Winifred Palmer, Ph.D*** **Coleen Weese, MD** **Robert Ryczak Ph.D*** **William Burrows, Ph.D, PE** **Glenn Leach, Ph.D**
Other Workgroup Members and Contributors:	**Jesse J. Barkley, Jr.** **Hsieng-ye Chang, PE*** **MAJ Theresa Cutler** **MAJ Beau Freund** **Jennifer Houser** **John Resta, PE** **Gail Robinson, Editor** **Theodore Ruff** **Thomas Runyon** **Kenneth Williams**

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This Technical Guide (TG) is designed to be used as a tool to assess the potential adverse health impacts among a "target population" consisting of healthy deployed military personnel resulting from chemical exposures. However, human responses do not occur uniformly at precise exposure levels but can extend over a range of concentrations. In all populations, there are hypersensitive individuals who many show adverse responses at exposure concentrations far below levels at which most individuals would normally respond. Therefore, these guideline levels are estimates of the thresholds above which there would be an unacceptable likelihood of observing the defined effects. Also, as the target population is assumed to be healthy, impacts of exposure to pre-existing conditions are not considered. Guidance levels suggested in TG 230A are based on available human and animal dose-response data for the chemicals listed. Although a variety of toxicological endpoints have been considered, not all endpoints were assessed. Further, the guidelines draw from a variety of sources. Doses protective against unacceptable carcinogenic, reproductive, and fetal developmental risks have not been clearly defined in all cases.

PREFACE

When military personnel are deployed in support of military operations, they may be exposed to harmful chemicals as a result of uncontrolled industrial releases, sabotage, or from the intentional or unintentional actions of enemy or friendly forces. Risks from such chemical exposures must be incorporated in the operational risk management process. Military health services personnel are responsible for assessing and recommending controls to minimize such health-related risks.

This Technical Guide (TG) is a tool to assist deployed military personnel when assessing the potential health risks associated with chemical exposures. Specifically, this TG is designed to assist the military health services personnel in their efforts to determine the *severity* of these potential health risks within a framework that is consistent with other military risk management decisions. Military health services personnel should, therefore, evaluate the information in this TG within the context of their own experiences in determining why, when, and how the information applies to a situation.

This TG is designed to correspond with the Department of the Army's Field Manual (FM) 100-14, *Risk Management*.[1] Other services have similar military operational risk management guidance. FM 100-14 and the other military risk management guidance apply across a wide range of military operations. This guidance explains the principles, procedures, and responsibilities to successfully integrate the risk management process to conserve combat power and resources to allow individuals to make informed, conscious decisions to accept risks at reasonable levels. TG 230A allows such decisions to be made regarding health risks associated with chemical exposures.

The proponent of this TG is USACHPPM. Due to scientific advances and expanding operational needs, this document will be updated as necessary; therefore, the user should ensure that he/she has the most updated version. Questions, comments, and recommendations should be forwarded to: Commander, USACHPPM, ATTN: MCHB-TS-EHR (V. Hauschild), APG-EA, 21010-5403; (410) 436-5213/DSN: 584-5213.

[1] The proponent of FM 100-14 is HQ TRADOC, ATTN: ATSBO-SO. Version April 1998 is used as a reference herein.

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SECTION 1 - INTRODUCTION

"*Both military leaders and their staffs manage risks. Staff members continuously look for hazards associated with their areas of expertise. They then recommend controls to reduce those risks. Leaders and their staffs become the assessors for ever-changing hazards such as those associated with environment (weather, visibility, contaminated air, water, soil), equipment readiness, individual and unit experience, and fatigue. Leaders should advise the chain of command on risks and risk reduction measures.*" (DA, 1998)

Whether engaged in major regional conflicts (combat) or deployed in stability and support operations (formerly known as "operations other than war") commanders are aware that there may be threats beyond that of an armed adversary. Deployed military personnel can be exposed to toxic chemicals, either intentionally or incidentally, from air, water, and to a lesser extent from soil. Exposure may occur through inhalation, ingestion, or skin contact. Such exposures may have significant immediate or even prolonged health effects. These health effects may adversely impact mission performance and/or may result in Disease and Non-Battle Injury (DNBI) during deployments. As such, risks to environmental chemical exposures must be assessed and integrated into overall military operational risk management.

1.1 Purpose

The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) Technical Guide (TG) 230A is a tool to assist deployed military personnel when assessing the risks associated with potential chemical exposures. Specifically, this TG is designed to assist the medical/preventive medicine personnel in their efforts to determine the *severity* of these potential health risks within a framework that is consistent with other military risk management decisions.

While interpretation of health risks associated with chemical contaminants will always require professional judgement, this TG provides information and examples to help evaluate data and to assess health risks from chemical exposures in deployment scenarios. Specifically, this TG should be used to characterize potential adverse health impacts associated with identified chemical hazards as well as to assess the potential severity of these hazards assuming temporary or short-term exposure periods. This information can then be used in accordance with the Department of the Army (DA) Field Manual (FM) 100-14, *Risk Management,* 1998 to establish the associated degree of risk to a deployed force. This guide may be used in the evaluation of pre-deployment and/or real-time environmental sampling data, or it may be used in conjunction with chemical source information and pre-deployment/post-deployment modeling to estimate the potential health risks that might result from accidental or intentional chemical releases. The exposure guidelines are not to be construed as mandated exposure limits or standards but rather as criteria to identify

potential risks that should be considered in deployment mission decision making and overall risk management.

1.2 Scope

This TG can be used to address potential health risks that may be experienced by deployed military personnel following temporary or short-term exposure to a number of toxic chemicals. It does not address biological or nuclear/radiation hazards. It addresses those scenarios in which personnel are deployed to a given location or are otherwise exposed to a given chemical for a temporary period of 1 to 14 days or less (during which time inhalation of airborne contaminants or ingestion or drinking contaminated water may pose risks). While health risks associated with nonpotable water and soil are also addressed in this TG, short-term concentration guidelines were not developed for these media since short exposures to these media are assumed not to be a substantial health threat. USACHPPM TG 230B, *Long-Term Chemical Exposure Guidelines for Deployed Military Personnel*, will address the risks associated with longer-term exposures (i.e., greater than 14 days up to 1 year). (Note: USACHPPM TG 230B is still under development at the date of publication of USACHPPM TG 230A.)

The guidelines in TG 230A are intended solely for use during military deployments and exercises outside the continental United States. They are not to be used to replace any Federal, State, local, or Army standards applicable in non-deployed situations, such as continental United States training exercises.

This TG is not designed for assessment of military personnel performing specific industrial operations (even those conducted during deployments) in which the conditions and frequency of exposures are similar to those in a civilian workforce. For example, when deployment activities (e.g., motorpool maintenance) involve typical 8-hour workdays, existing industrial hygiene standards that are more appropriate should be used (i.e., the guidelines in this TG may be overly cautious as they assume more continuous exposures up to full 24-hour days).

1.3 Audience

This TG is intended for use solely by military health services personnel trained in the evaluation of potential environmental exposures to chemicals during deployments. It is not designed for use by untrained personnel or as a substitute for having trained preventive medicine personnel onsite or in theater.

1.4 Application

As stated previously, applications of the guidelines provided in this TG may involve direct or "real-time" comparisons of field data and may also include pre- and post-deployment evaluations of modeled data. In any application, these guidelines are not to be construed as a strict delineation of the dose above which adverse health effects will occur. These guideline levels are provided for specified exposure duration and are based on a variety of effects, ranging from mild signs or symptoms and long-term delayed effects (from low-level concentrations) to more severe effects such as death (from temporary high concentration exposures). In some cases, exceeding these guidelines could cause immediate adverse health effects that may impact upon the ability of personnel to accomplish their immediate mission. In other cases, the delayed health effects resulting from long-term exposures may need to be considered when weighing a multitude of risks.

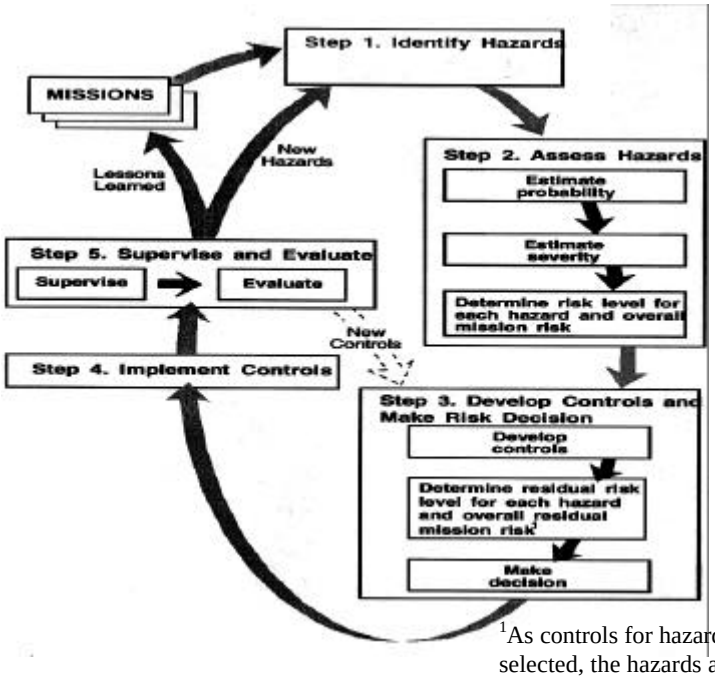
The severity and duration of the effects experienced depend on many things, including: (1) the sensitivity of the exposed individual; (2) the duration of exposure; (3) the concentration of the substance; and (4) the combination of substances to which the individual is exposed. If concentrations of detected chemical compounds consistently fall below the 1-hour guidelines for minimal effects, negligible risk would be expected for temporary exposures. Similarly, one may assume that there is minimal, if any, risk from exposure to those contaminants at concentrations below the 1-14 day guidelines for the described exposure duration. However, the guidelines presented in this TG are not a substitution for sound professional judgment and must be used in context with the user's experience and unique site-specific considerations.

Military health services personnel should use the information provided herein within the context of their own knowledge, experiences, and professional judgment. "Professional judgment" assumes that the individual using these guidelines will have a basic understanding of potential health effects associated with chemical exposures. The user must be prepared to make "best-guess" determinations in assessing the degree of severity posed by given chemicals in exposure scenarios and then must be able to translate this information into the risk matrix established by FM 100-14, *Risk Management*. The *Risk Assessment Matrix* from FM 100-14, (see Figure 2), first suggests a categorization of the severity of an identified hazard (in this case a chemical exposure), and secondly requires a categorization as to the probability of the hazard occurring. In this case, both first-hand and intelligence-based information (Defense Intelligence Report, 1999) can be used to determine the probability that a given exposure and concentration will be present over a certain period of time. The severity and probability of a hazard are then assessed to ascertain the risk level.

1.5 Limitations of Use

Mission, Multiple Risks, and a Changing Environment. The information provided in this document will assist military health services personnel in providing pertinent information to commanders to allow them to make informed decisions and manage overall risks in the course of the ever-changing deployment environment. The risk management process, particularly in a military operational/deployment environment, is not a single GO-NO-GO determination but must incorporate constant evaluations and re-assessments of the controls, measures and other risks. For example, in certain scenarios, attempts to "protect" military forces from any harmful exposure to a chemical might, in many deployment scenarios, result in other potentially more significant health risks. For example, preventing exposure to chemicals may require wearing bulky personal protective gear that reduces individual mobility and awareness of conditions. As another example, if troop movements are unduly altered to avoid potential chemical exposures, personnel may be more likely to risk enemy ambush. In the case of drinking water, the adverse health effects of dehydration may need to be weighed against exposure to certain chemicals in the available water source. It is, therefore, necessary to ensure that risks from chemicals are appropriately balanced with the risks from other deployment hazards.

This constant reassessment of potential risks to deployed military personnel and the associated residual risks from control measures is part of the overall risk management continuum as depicted in Figure 1 below.



[1]As controls for hazards are identified and selected, the hazards are reassessed as in Step 2.

Figure 1. Continuous Application of Risk Management
(FM 100-14, *Risk Management*

Guidelines versus Standards: During deployment, the field commander must make decisions about which risks are necessary to accomplish the mission. The military health services personnel are there to assist with assessing health risks and the potential implications of these risks. They also help to succinctly present this information and any suggested corrective actions so the commander will be able to make an educated decision. As this TG is a tool to assist with identifying potential health risks, it does not present standards or definitive decision criterion to which a commander must adhere.

Definitive Risk Assessments: Risk assessments, particularly under "real-time" time constraints, will require expediency and professional judgment as previously described. They may even require additional expertise such as direct consultation with USACHPPM. In many instances, it will be difficult to make definitive statements as to the severity of the health risk. At best, the goal is to identify and provide some definitive statement as to the severity of the health risk. However, statements regarding whether a risk is present or not must be carefully stated to ensure that the uncertainty inherent in any risk assessment is accurately considered and weighed.

SECTION 2 - GENERAL EXPOSURE CONSIDERATIONS AND ASSUMPTIONS

2.1 Exposure Duration

Exposure duration is one of the major factors affecting the severity and characteristics of toxic effects that may be experienced by exposed individuals. A short exposure to a chemical may produce only minimal health effects such as mild irritation; whereas, longer exposures to the same chemical concentration may produce more severe effects which could interfere with mission function. Deployed military personnel exposed to chemicals will experience a wide range of exposure duration. This TG provides exposure guidelines for only a few selected exposure duration scenarios which will not exactly fit every situation. The user of this TG must exercise judgment in applying these guidelines to specific actual exposure scenarios.

The two inhalation exposure scenarios used in this TG are temporary exposures of 1-hour and short-term exposures of 1-14 days. Currently, this TG does not specifically provide guidelines for exposure duration between 1 and 24 hours. The severity of risk for exposure duration between 1 and 24 hours may be estimated by comparing the temporary and short-term exposure duration guidelines to the anticipated/known exposure duration.

Temporary exposure periods, in general, are defined as brief single exposures that could last minutes to hours (some references would classify this as “acute” exposure periods). For the purposes of this TG, temporary exposure will be represented as a 1-hour time period. The 1-14 day period is considered short-term (some references classify this as a “sub-acute” exposure duration). Similarly, the drinking water guidelines apply to exposure periods of less than 5 days and to periods of 5 to 14 days; these are both considered short-term duration in this TG**.** Refer to Section 4.2 - 4.3 for more discussion regarding air guidelines and to Section 5.4 for a more detailed discussion of potable (drinking) water guidelines.

In some situations, particularly during stability and support operations, military personnel may deploy to a specific site for periods as long as 1 year. The guidelines in this TG do not apply to exposure duration exceeding 14 days. USACHPPM TG 230B will address the risks associated with long-term exposures (i.e., greater than 14 days up to 1 year).

2.2 Exposure Frequency

Exposure frequency is another critical factor in estimating severity and onset of health effects from a chemical exposure. Exposure frequency describes how often continuous exposures have occurred during a specific time period. Contrast this with exposure duration which describes the overall time period during which individuals may have been, or are expected to be, exposed to a

chemical. Within a specific time period, an individual may move away from the source of the chemical exposure or there may be periodic interruptions in the release/concentration of a chemical hazard. For example, the frequency of exposures of the civilian workforce to chemicals through inhalation is generally assumed to be 8 hours/day, 5 days/week, for a 30-year exposure duration.

In contrast, deployed military personnel will experience shorter exposure duration since these personnel are rarely deployed for periods greater than one year. However, the exposure frequency for those deployed military personnel may be much greater. For example, those deployed personnel may be exposed continuously 24 hours/day, 7 days/week. This scenario is based on typical field living conditions which may be characterized by repeated or continuous open and direct contact with environmental media, increased physical activity, greater temperature and climate extremes, and poor sanitary conditions. TG 230A guidelines were derived with these types of possible deployment exposure frequencies in mind.

Air: The guidelines in this TG are based on the assumption that exposures are single, continuous events and represent an averaged exposure concentration over the specified time period. The number of subsequent exposures that would be relevant to a specified guideline and associated duration cannot be definitively determined; therefore, it will require professional judgement to determine the most suitable guideline to use for a given scenario. It may be assumed that multiple subsequent exposures may increase the probability of experiencing adverse symptoms within a specific deployment. For example, if temporary inhalation exposures (1-hour) were to be intermittently repeated (e.g., every few hours an exposure would occur, then subside, only to be repeated again, with this occurring over several days), the temporary 1- hour guideline representing minimal severity may not appropriately represent the true potential for health risks.

In some cases, short-lived increases in exposure concentrations, often referred to as “peaks” or “excursions” that occur during a more extended exposure period, may be of greater concern than estimating an average overall concentration. For example, if one was to anticipate a week-long exposure period and the estimated average concentration is less than the 1-14 day guideline, it may still be necessary to establish whether any peak exceedances of the 1-hour guidelines occurred. This same concept applies to exposures that may involve multiple, subsequent 14-day exposure periods. Specifically, users are recommended to consult the long-term guidelines (USACHPPM TG 230B) for exposures exceeding 14 days as well as for considering multiple 14-day exposures. Ultimately, one must consider both the cumulative dose over a period of time as well as any peaks or excursions in potentially high concentrations.

Field Drinking Water: With drinking water, the exposure is based on the rate of daily consumption of water. Department of Defense (DOD) guidance (DA 1983) estimates the maximum quantity of consumed water by the average military personnel deployed in a temperate environment to be 5 Liters (L)/day. The maximum consumption rate increases to 15 L/day for

deployment in arid environments. *[It should be noted , however, that the U.S. Army Office of The Surgeon General is now advising that maximum daily fluid consumption should not exceed 12 quarts (about 11.5 L/day)]* (Memorandum 1998). The water guidelines in this TG are based on these daily consumption rates for the specified period of time. As described above for the air guidelines, it is also important to factor the real-world variability in rate of exposure (in this case rate of consumption) when assessing potential health risks associated with drinking water. This includes considering potential high concentration peaks of chemicals during an extended duration, intermittent increased consumption rates, or subsequent duration periods beyond that originally anticipated. Ultimately, one must consider both the cumulative dose over a period of time as well as any peaks or excursions in potentially high concentrations. Refer to Section 5.7 for a more detailed discussion.

2.3 Population Assumptions

The guidelines in this TG are based on the assumption that deployed military personnel consist of healthy and fit male and female adults. Deployed military personnel are assumed to be 18 to 55 years of age, with an average weight of 70 kilograms with no predisposing physical or mental factors which could be exacerbated by exposure to environmental pollutants. This TG contains no special considerations to protect individuals with predisposing health conditions. Where data on developmental (fetal) toxicity and reproductive effects were available, these endpoints were considered and used in developing these guidelines; however, due to the limited available data, these guidelines should not necessarily be construed as protective against such effects.

These guidelines have been prepared drawing from a variety of governmental and non-governmental sources which were developed for varying applications (i.e., different target populations to include emergency personnel, civilian workforce, and the general population to include sensitive sub-populations).

The guidelines presented here are based on available information from human and animal study data as well as from documented occupational exposure information. The quality and availability of toxicological data varies from substance to substance. Furthermore, the toxicological basis for the guidelines differs depending on the substance. These guidelines have been prepared drawing from a variety of governmental and non-governmental sources which were developed for varying applications, and for different target populations including emergency personnel, the civilian workforce, and the general population. Sensitive sub-populations are considered in the general population guidelines.

Extraneous factors may reduce or aggravate expected exposure outcomes. For example, occasional breaks in exposures or exposure-free periods may reduce potential health effects by allowing the clearance and elimination of substances from the body that accumulate during

exposure. Conversely, increased physical workload in a deployed military population may actually increase the probability of occurrence and the severity of adverse health effects because factors like breathing rate or water consumption rates increase as workload increases leading to an increased uptake of chemicals. While workload/increased physical activity and other stresses in a deployed military situation were partially considered in establishing some of these guidelines, certain extremely strenuous activities and conditions that increase breathing rates and water consumption rates could increase the severity of effect.

2.4 Toxicological Endpoint

These guidelines apply to temporary (1-hour) inhalation exposures and to short-term (1-14 day) inhalation and ingestion exposures. For the most part, the toxicity studies that address such exposure duration evaluate the adverse health effects that appear either during or shortly after exposure. In the case of airborne chemicals, such effects can include irritation and tissue damage following direct contact with tissues of the eye, skin, or respiratory tract. When chemicals are ingested, irritation may occur after contact with the mouth, esophagus or stomach, although concentrations of irritants are rarely high enough to be of concern in drinking water. Other effects result from systemic toxicity in which the chemical is transported to susceptible target organs such as the central nervous system (CNS), kidney, or liver via the lymphatic or circulatory system. Certain acute (i.e., severe to catastrophic) effects may reduce in severity after exposures cease, allowing for elimination and recovery, although at catastrophic levels there is the potential for death. Some short-term exposures may produce delayed effects, such as cancer, reduced fertility or sensitization to further exposures. Data on delayed effects after short-term exposures are limited but, when available, they were considered in selecting/deriving the guidelines in this TG.

Appendices C and D present the adverse health effects that may be experienced if these guidelines are exceeded. The 1-hour air inhalation guidelines include three concentration levels corresponding with adverse effects ranging from *minimal* to *significant* to *severe*. Significant adverse effects should not occur to most deployed military personnel if exposures are below the suggested air and water guidelines for 1- to 14-day exposures. The risk of experiencing symptoms and effects increases in probability as concentrations of contaminants increase above the stated guidelines. Individual sensitivities, concentrations of the chemical in one or more media, and the duration and frequency of exposures all determine the type of response and magnitude of effect. For chemicals that are irritants, the concentration in air or water may be more important than the duration of exposure in determining the severity of the effect. The concentration of a chemical and the duration of exposure may be equally important in determining the nature and severity of chemicals that have systemic effects.

2.5 Carcinogenicity

The exposure guidelines in this TG are not based on cancer risks associated with temporary or short-term exposures. However, the preparation of this TG required an assessment of cancer risks from exposures to carcinogens since the current state of knowledge concerning the mechanisms of cancer can neither prove nor discount the possibility that a single chemical exposure event is sufficient to cause cancer. Non-carcinogenic toxic effects are usually determined using data from animal and human studies. These studies attempt to define an "effect" or "no-effect" level for a given exposure to a certain chemical. This approach assumes that there is a threshold concentration or exposure level below which no effects occur. In contrast, carcinogens are not thought to have a threshold concentration or dose below which they will not induce cancer. Therefore, a "no-effect level" cannot be reliably quantified for carcinogenic chemicals.

Mathematically, a relative cancer risk can be calculated for even the brief periods of exposure in this TG (i.e., 1 hour and 1-14 days). In fact, these calculations were performed and considered in the derivation of certain existing U.S. guideline levels discussed in this TG (see Section 4). Yet none of the actual guidelines were based on the calculated cancer risk because the resulting cancer-based concentrations, while calculated to be adequately protective against cancer, were not deemed to be protective against non-carcinogenic effects. There are additional concerns that the models used do not adequately address certain mechanisms such as the effects of age, the variation in repair mechanisms, and detoxification that can be operative in the low dose ranges. For these reasons, the guidelines in this TG are not based on cancer risks associated with temporary or short-term exposures. USACHPPM TG 230B does directly address cancer risk and incorporates carcinogenic potency into the development of the guidelines. Further documentation and discussion of this issue can be found in the supporting companion document to this TG, USACHPPM Reference Document (RD) 230A.

2.6 Odor Thresholds

Odors in air and water and tastes in water can indicate the presence of undesirable contaminants that may or may not pose a health risk. Odors and tastes can be useful as predictive or warning tools and can further assist the evaluations of military health services personnel. Absence of odors or tastes does not guarantee that the air or water is free of contamination. Refer to Sections 4 and 5 for more discussion.

SECTION 3 - DATA EVALUATIONS

3.1 General

To reemphasize, this TG does not establish "standards" that must be strictly adhered to, nor does it represent a comprehensive health-risk assessment. It is a tool to complement the knowledge and professional judgement of trained military health services personnel who may be required to inform their commanders of potential adverse health effects caused by environmental conditions and to identify potential impacts on the mission. This TG provides the evaluation criteria and methods to facilitate cautious, yet defensible, logical, and consistent decision making. The decision to minimize the potential health risks by avoiding exposure to particular adverse environmental conditions will always need to be balanced against the requirements of the mission itself. These decisions are ultimately those of the commander. It is the medical/ preventive medicine officer's role to ensure that the commander has the essential information to make the most appropriate decision.

As identified in Section 1.1, this TG should be used in the second step of the overall risk management continuum (see Figure 1) prescribed by FM 100-14 - the process of hazard analysis through data evaluation. Specifically, this TG assists with evaluating the *severity* of a hazard. This information must then be evaluated against the *probability* of such an exposure situation to occur for the anticipated duration or exposure. Together, the *severity* and *probability* of a chemical's anticipated exposure hazard can then be used in the FM 100-14 *Risk Assessment Matrix* to determine the degree of risk for the purpose of decision making and risk management. See Figure 2 below:

RISK ASSESSMENT MATRIX					
	PROBABILITY				
SEVERITY	**Frequent**	**Likely**	**Occasional**	**Seldom**	**Unlikely**
Catastrophic	E	E	H	H	M
Critical	E	H	H	M	L
Marginal	H	M	M	L	L
Negligible	M	L	L	L	L
E - Extremely High Risk **H - High Risk** **M – Moderate Risk** **L - Low Risk**					

Figure 2 - Risk Management
(FM 100-14, *Risk Management*)

3.2 Considerations When Applying or Comparing Guidelines With Data

Despite the presentation of numerical guidelines in this document, substantial professional judgment as discussed in Section 1.4 is required to provide an overall assessment of environmental conditions at a site. The user of this TG should become familiar with the basis/assumptions and limitations associated with the numerical criteria presented in the tables, as described previously in this TG. Unique issues regarding severity of risks described in sections 4.2 and 4.3 (for air/inhalation exposures) and section 5.7 for drinking water should be considered. Appendix E, *Data Evaluation Examples,* provides scenarios and theoretical examples of how these guidelines may be applied in various situations.

3.3 Multiple Contaminants

The guidelines in this TG are for exposure to single substances. Simultaneous exposure to many substances may produce additive, antagonistic, or synergistic effects. Since the toxicity of combinations of substances have been experimentally determined for very few compounds, these guidelines cannot address the potential effects of multiple, simultaneous exposures in a quantitative evaluation. While the guidelines themselves are applicable to exposures to each substance alone, target organ considerations may be used in a qualitative manner to address exposures to multiple contaminants. In addition, as information becomes available, any known chemical interactions will be indicated in the "Notes" columns of Appendices C and D (however, if no indication is made it should NOT be assumed that there are no interactions). Appendix E, *Data Evaluation Examples,* Scenario 1, demonstrates a situation and considerations where multiple chemicals are indicated.

3.4 Multiple Pathways

In addition to the potential additive or synergistic effects of multiple contaminants, military personnel may be exposed to the same contaminants from multiple sources (such as both air and water) or from multiple exposure pathways (such as dermal and inhalation exposures). Thus, the potential for combined and increased deleterious health effects would need to be considered. Consideration should be given to the potential additive effects of being exposed to the same or similar compounds through both air and water. Appendix E, *Data Evaluation Examples,* Scenario 1, demonstrates situations and considerations where a chemical is present in several environmental media.

SECTION 4 – MILITARY AIR GUIDELINES – SHORT TERM (MAGs-S)

The following section describes the basis for the air (inhalation) guidelines in this document and for the basis for each guideline value. For more detailed information and explanation as to how chemicals were selected for inclusion, refer to the companion document to this TG, USACHPPM RD 230A.

4.1 General

Appendix C contains air contaminant guidelines for 1 hour and 1- to 14-day exposures. These guidelines are referred to as Military Air Guidelines – Short Term (MAGs-S). The values selected for use as MAGs-S were derived from sources including the American Conference of Governmental Industrial Hygienists (ACGIH), the American Industrial Hygiene Association (AIHA), the U.S. Environmental Protection Agency (EPA), the Agency for Toxic Substances and Disease Registry (ATSDR), the National Research Council (NRC), and other organizations. Each compound listed in Appendix C is identified by chemical name, sometimes with a synonym, and a Chemical Abstracts Service (CAS) number. (The CAS number is a unique identification number assigned by the CAS of the American Chemical Society. The CAS numbers have been assigned for over six million chemicals.)

Environmental exposures to air contaminants measured during recent deployments have generally been well below the guidelines presented in Appendix C. However, some data suggest that significant levels of air contaminants might occur in the immediate vicinity of local activities normally conducted during deployments. Examples of such activities include open burning, small-scale incineration, bulk-fueling operations, the use of bulk pesticides for insect control, and the use of combustion heaters inside poorly ventilated tents. The intentional use of industrial chemicals as weapons (e.g. in the destruction of large-scale storage facilities) may also expose deployed military personnel to localized high levels of some airborne contaminants.

Concentrations of toxic chemicals in air necessary to produce acute immediate or short-term health effects are much closer to emergency or occupational exposure guidelines than they are to ambient environmental air quality criteria or standards. Ambient air quality criteria are usually derived to protect the general population against chronic health effects from a lifetime of low-level exposure. Consequently, the MAGs-S in Appendix C were derived primarily from emergency, military, and occupational exposure criteria, though in several cases where such criteria did not exist, the more protective (general population) criteria were used.

4.2 One-Hour Values

The 1-hour values represent three levels of hazard severity. These levels represent a *minimal* health effect level, a *significant* effect level, and a *severe* effect level. These categories of effects parallel those established as emergency guidelines by various agencies which are used as planning tools to determine procedures and plans to minimize risks from accidental chemical releases. The values in this TG, therefore, provide the user with a range in which to estimate the severity of the situation. Concentrations below the minimal effect levels may be considered safe or of "negligible severity" for most individuals from inhalation exposures to a specific chemical. Individuals exposed to concentrations between the minimal and significant effect levels may be considered to be in a "marginal severity" category where military personnel would experience mild irritation or temporary health effects. Individuals exposed to substance concentrations between the significant and severe effect levels may be considered to be in a "critical severity" risk category where deployed military personnel should not experience or develop irreversible health effects or symptoms that would impair their ability to take protective action. Individuals exposed to air concentrations exceeding the severe effect levels would be considered to be of "catastrophic severity" where irreversible or life-threatening health effects may occur.

Given the basis for selection of the existing values from which these guidelines are based, and since the response time varies with individual sensitivities that may depend on the chemical-specific mode of action and mechanism that produces effects, the 1-hour duration is only an approximate value. That is, certain individuals may experience these effects at exposure intervals shorter or longer than 1 hour. (Refer to Section 2.1 - 2.3.)

These MAGs-S are a compilation of published 1-hour values from Emergency Response Planning Guidelines[(ERPGs) AIHA]; Acute Exposure Guidelines Levels [(AEGLs) National Advisory Committee (NAC)/EPA]; and Temporary Emergency Exposure Limits [(TEELs) Department of Energy (DOE)] in this hierarchical order. Other values were used where appropriate and consistent with the application and effect levels. These were Emergency Exposure Guideline Levels [(EEGLs) NRC]; Short-term Public Emergency Guideline Levels [(SPEGLs) NRC], Ceiling Limit values (ACGIH), and Immediately Dangerous to Life and Health [(IDLH) National Institute of Safety and Occupational Health (NIOSH)] values. The IDLH values were consistent with *severe* effects and were used when no other comparable values were available. The EEGLs were found to be consistent with *significant* effects and were used when appropriate; the SPEGLs and Ceiling Limit values were found to be consistent with *minimal* effects and were used where appropriate. The basis for and more technical discussion of this hierarchy selection process can be found in TG 230A, the companion document to USACHPPM RD 230A.

In certain circumstances, identical values may appear in categories identifying different levels of severity. These are cases where limited data were available to delineate between these levels. In these cases, any exceedance of these guideline values may result in effects that may be considered applicable in either category.

4.3 1- to 14-Day Values

The MAGs-S for 1- to 14-day inhalation exposures represent concentrations of chemicals in the air that are not expected to produce significant health effects in the deployed population for continuous exposures (e.g., 24 hours/day) up to 14 days in duration. The sources of the values in Table C include published Continuous Exposure Guidance Levels [(CEGLs) NRC]; acute Minimum Risk Levels (MRLs) (ATSDR); Threshold Limit Values [(TLVs®) ACGIH]; and Ceiling Values (ACGIH), in this hierarchical order. CEGLs were specifically developed for military personnel experiencing continuous inhalation exposures for up to 90 days. Therefore, the CEGLs were given highest priority in developing MAGs-S. These values, unlike the EEGLs, were designed to avoid adverse health effects (immediate or delayed) for prolonged periods (up to 90 days, and not solely for emergencies). Acute MRLs are intended to apply to continuous exposures of up to 14 days. The MRLs are values derived for the general population and include uncertainty factors (UFs) to protect sensitive sub-populations. MRLs were used in preference to TLVs since they were designed specifically for 14-day exposure periods. Finally, chemicals that had ceiling values (ACGIH) were annotated in Appendix C with these ceiling limits as the MAGs-S (see Section 4.4).

The adaptation of existing occupational criteria (i.e., the TLVs) to guidelines intended to apply to continuous exposures in a deployment scenario considered several important factors. The TLVs are Time-Weighted Average (TWA) criteria that are based on exposures for a working lifetime (approximately 30 years), 8 hours/day, 5 days/week, 50 weeks/year. The TWAs assume 2/3 of each day to be without exposure, during which time some clearance and detoxification may occur. Such breaks in exposure may not occur in typical deployment exposure scenarios, though ambient conditions may fluctuate. Therefore, based on the ACGIH documentation, the TLVs were grouped according to the type of effects expected [systemic toxicity, irritation, or both (mixed)].

The TLVs for all systemic-acting substances (including mixed) were divided by a UF of 10. This UF of 10 accounts primarily for the lack of breaks in exposure in continuously exposed,

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deployed military personnel that would normally allow limited clearance and detoxification to occur. These guidelines may be re-evaluated in respect to this modification as necessary. The TLVs for compounds acting only as irritants were not modified for this TG. To a certain extent, the added stress, fatigue, nutritional status, and increased workload/activity levels that may be faced by deployed military personnel can also result in increased susceptibility of the deployed individual as compared with a typical industrial worker. The UF of 10 used for systemic-acting chemicals may account for some of these concerns, but there are no empirical data to quantitatively establish an adjustment factor for these issues for each chemical.

Since no adjustment is made to the TLV for irritants, it should be specifically noted that the stresses and increased physical activity experienced by deployed military personnel may increase the probability of occurrence and/or the severity of effects. Exceptions and modifications of the procedures to establish 1- to 14-day MAGs-S have been made for some compounds based on data used for TLV extrapolation and the intended application as described herein. For more detailed information, refer to the companion document to this TG, USACHPPM RD 230A.

4.4 Special Chemicals

Concentration-dependent: Effects caused by some substances, for example many irritants, depend more on the chemical concentration than the length of time individuals are exposed. It is for these substances that TWAs are not appropriate. Ceiling values (ACGIH) have been developed for these substances and are concentration, not time dependant. These are values that should not be exceeded for any duration at the threshold effect level. Ceiling values are annotated by a "**c**" in Appendix C. The MAG-S is, therefore, stated as the ceiling value itself.

Absorbed through skin: Other substances can be appreciably absorbed through the skin. These substances are noted within the tables with an "**s**" in Appendix C. Caution must be exercised when concentrations for these substances approach the indicated MAG-S since dermal absorption may contribute to the overall toxic effects and, as such, are not accounted for in the indicated guideline values. Specifically, inhalation of concentrations at the MAGs-S levels may be of concern because additional amounts of the chemical can be introduced to the body via both inhalation and the skin.

Chemical Warfare Agents: Given the unique military purpose for chemical agents, published values from the aforementioned sources were not found. Therefore, values for agents were obtained from either reviewed military-specific literature or from military-sponsored NRC publications. The 1-hour MAGs for these agents are consistent with the minimal, significant, and severe levels described previously. Since the data from which these values were based were developed for a different purpose (offensive use), values consistent with a significant level of effect were not available. Therefore, only minimal and severe level values are present. The 1- to

14-day MAGs-S for chemical agents were based on Army/DOD worker 8-hour TWA values with a UF of 10 applied. For a more detailed discussion, refer to the companion document to this TG, USACHPPM RD 230A.

4.5 General Air Quality Measures

In the U. S., the EPA uses six "criteria pollutants" as indicators of basic ambient air quality and has established for each of them a maximum concentration above which adverse effects on human health may occur. These threshold concentrations are called the National Ambient Air Quality Standards (NAAQS). The criteria pollutants are ozone, particulate (also see Section 7), carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen dioxide (NO_2) and lead. These pollutants are emitted from a variety of sources including factories, power plants, incinerators, transportation, construction activity, fires, and natural windblown dusts.

Most of these criteria pollutants are of particular concern for sensitive sub-populations such as the elderly, children, or those who have pre-existing health conditions such as cardiovascular disease or lung conditions (e.g., asthma or chronic obstructive pulmonary disease). Though healthy adult military personnel may be considered less susceptible to these effects, studies have indicated that, at high concentrations, these pollutants can affect even healthy adults after short-term exposures by causing symptoms such as increased mucous or cough, reducing lung function, or increasing chance of respiratory inflammation or infection. Such effects may be more likely in individuals performing strenuous activities and, as such, may be important in controlling the level of activities that are required of deployed military personnel.

Specific MAGs-S are provided in this TG for carbon monoxide, sulfur dioxide, and nitrogen dioxide (see Appendix C). Lead is a concern in ambient air for long-term duration and, therefore, is addressed in USACHPPM TG 230B.

Ozone (O_3) may cause minimal to significant health problems even after temporary or short-term exposures by damaging lung tissue, reducing lung function, and sensitizing the lung to other irritants. Irritation will be the first symptom experienced by healthy individuals. O_3 is the major component of smog and is formed through complex chemical reactions between industrial pollutants in the presence of sunlight. Therefore, brighter sunlight and warmer temperatures will result in elevated O_3 levels where there is significant pollution. Military-specific concentration guidelines are not available at this time for O_3. Instead, deployed military personnel should consider the environmental conditions when determining whether O_3 may be a concern. For example, in polluted environments during extremely hot sunny days, commanders may want to consider minimizing activity levels, particularly during the hottest times of the day.

Air pollutants called **particulate matter** include not only dust and dirt, but also soot, smoke and liquid droplets directly emitted into the air by sources such as factories, power plants, cars, construction activity, fires, and natural windblown dust. Increased exposure to particulates in air can result in respiratory irritation, inflammation, or an increased incidence or severity of existing lung disease, such as asthma. It is unlikely that respirable particulate concentrations would reach levels associated with *significant* or *severe* (life-threatening) health effects after short-term exposures in the normal healthy deployed population, yet increased exposure may decrease military personnel performance and degrade their effectiveness. Individuals with asthma or bronchitis would be the most likely to demonstrate effects. Environmental influences such as wind and low humidity may increase airborne particulate levels in certain circumstances.

For reference, the EPA general population index values for particulates are provided below. The user should note that these values do not portray exactly the same levels of risk represented by the MAGs in Appendix C of this TG; the index ranges are only provided to make relative comparisons to U.S. guidance regarding recommended activity levels for different levels of air quality. In general, while the severity of Level 1 indicated below is comparable to a *minimal* effect level in Appendix C, Levels 2 and 3 are somewhat less severe than *significant* and *severe* MAGs.

Table 1 - U.S. General Population Index Criteria for Particulate Matter (PM_{10})

Level (ascending hazard level)	Concentration ug/m^3	General Civilian Population Health Effects Statements	General Civilian Population Health Effects Statements
1	255-354	Increased respiratory symptoms (e.g. coughing) and aggravation of lung disease (e.g., asthma)	Elderly, children, and people with lung disease (e.g., asthma) should restrict heavy exertion; others should minimize prolonged exertion
2	355 - 424	Significant increase in respiratory symptoms (e.g. coughing, mucous) and aggravation of lung disease (e.g. asthma)	Elderly, children, and people with lung disease (e.g., asthma) should avoid outdoors; others should minimize moderate to heavy exertion
3	425 - 604	Serious risk of respiratory symptoms (e.g. coughing, mucous, shortness of breath) and aggravation of lung disease (e.g. asthma)	All should minimize outdoor exertion

[Environmental Protection Agency, *Guideline for Reporting of Daily Air Quality –Pollutant Standards Index (PSI) DRAFT*, 1998.]

SECTION 5 - MILITARY WATER GUIDELINES – SHORT TERM (MWGs-S)

The following section describes the basis for the drinking (potable) water guidelines in this document. For more detailed information and explanation as to how chemicals were selected for inclusion, refer to the companion document to this TG, USACHPPM RD 230A.

5.1 General

Appendix D contains short-term exposure guidelines, Military Water Guidelines - Short Term (MWGs-S) for drinking water contaminants for 5-day and 2-week exposure duration at two rates of water consumption: 5 L/day and 15 L/day. These two maximum consumption rates have been established by the military to sustain adequate hydration of deployed military personnel in different climates and were based on temperature, acclimation, and workload. In temperate climates or conditions, the estimated rate of consumption is 5 L/day. In arid regions or conditions, including arctic regions, the estimated rate of consumption is 15 L/day.

The short-term water quality guidelines were derived from 1-day and 10-day Health Advisories developed by the EPA (EPA 1996). When short-term Health Advisories developed by the EPA were available for chemicals that also had military guidelines, the existing DOD Tri-Service Standards and the military doctrine in Technical Bulletin, Medical (TB MED) 577, *Sanitary Control and Surveillance of Field Water Supplies*, (DRAFT) 1996, were given precedence over the short-term EPA Health Advisories. Acute oral MRLs were used for a few compounds which were not addressed in TB MED 577 and for which there were no EPA Health Advisories. Compounds in which MWGs-S were derived from TB MED 577 or from ATSDR acute MRLs are indicated with single and double asterisks, respectively, in Appendix D.

Most of the MWGs-S were derived from the EPA Health Advisories. The Health Advisories are not enforced regulatory standards but rather recommended drinking water quality guidelines for exposure duration of 1 day, 10 days, longer-term (for up to approximately 7 years), or a lifetime. The Health Advisories are designed to protect the more sensitive members of the general population including children and the elderly. For compounds with sufficient reproductive toxicity data, the Health Advisories are also protective of the developing fetus. In some cases, when it was clear that the EPA Health Advisories were overly protective of healthy adults, a "military adjustment factor" (MAF) was applied to EPA values to derive MWGs-S more applicable for deployed military personnel. Such cases are indicated in the "Notes" column of Appendix D and are explained in detail in the companion document to this TG, USACHPPM RD 230A. The EPA 1-day and 10-day Health Advisories are based on the weight of a 10-kilogram child consuming 1 L of water each day. These values were adjusted to become the military

exposure guidelines in this TG, based on a 70-kilogram adult consuming 5 L/day in temperate environments or 15 L/day in arid environments.

The DOD Tri-Service standards were developed for the individual consuming either 5 or 15 liters of water per day for periods of 7 days or less or for periods of more than 7 days up to 1 year. Because they do not include UFs to protect members of the general population who may be unusually sensitive to the effects of chemicals, the DOD Tri-Service standards are less conservative (i.e., less protective) than the MWGs-S derived from the EPA Health Advisories. However, no adverse health effects should be experienced if the concentration of chemical substances in water is equal to or lower than the concentration indicated by the MWGs-S and if the water is consumed for no more than the specified time period.

With the exception of the TB MED 577 standards, the MWGs-S in this TG are not standards and are not to be used to outright approve or disapprove field drinking water supplies. Instead, they are intended as a screening tool to be used solely by military health services personnel. The MWGs-S are useful for interpreting water quality data, assessing degrees of risk associated with that water quality, and communicating that risk to the tactical commander in making sound, operational risk-management decisions. (See Section 5.8 for additional discussion.)

5.2 5-Day Values

Appendix D contains guidelines for exposures to contaminants in drinking water for two rates of water consumption (5 and 15 L/day) for a period of up to 5 days or less. Most of these guidelines were based on the 1-day EPA Health Advisories which were designed as one day limits but included a 4-day margin of safety, and thus, are actually protective for a period of 5 consecutive days. Therefore, the 5-day MWGs-S represent concentrations of chemicals in drinking water that are not expected to cause any adverse non-carcinogenic effects for up to 5 consecutive days of exposure.

The short-term chemical standards for the 14 chemicals in TB MED 577 are listed, unaltered, in the 5-day column in Appendix D. The physical, microbiological, and radiological standards from TB MED 577 were not included in this TG. Note that while the DOD Tri-Service Field Water Quality Standards (TB MED 577) were derived for exposures for up to 7 consecutive days of consumption, unlike the MWGs-S derived from the EPA Health Advisories, there is no safety margin provided for in the DOD standards. Therefore, unless a 5-14 day MWG-S value is provided for chemicals with TB MED standards, the duration of exposure should not exceed 7 days as potential health effects are more likely to occur. (See Section 5.7.)

5.3 14-Day Values

Appendix D provides short-term guidelines for exposures to chemical substances in drinking water for periods up to 14 days. The 14-day MWGs-S represent concentrations of chemicals in drinking water that are not expected to cause any adverse, non-carcinogenic effects for up to 14 consecutive days of exposure.

Most of the 14-day guidelines in this TG are derived from the EPA 10-day Health Advisories adjusted for weight and rate of drinking water consumption in the same way as for the 5-day guidelines. The EPA 10-day Health Advisories provide a safety margin of four days and are not expected to cause any adverse, non-carcinogenic adverse health effects if exposure is limited to 14 consecutive days of exposure.

For those 14 short-term chemical standards taken from the DOD Tri-Service standards in TB MED 577, no entries were made in the 14-day columns except for the five substances (cyanide, chloride, lindane, magnesium, and sulfate) whose DOD 7-day standards are the same as the DOD 1-year standard. Exposures to the remaining DOD compounds should in no case be allowed to exceed the 7-day limit.

5.4 Current Military Field Drinking Water Standards

Tri-Service doctrine and numerical standards for the sanitary control and surveillance of field water supplies are presented in TB MED 577. A summary of the guidelines is presented below.

Appendix D includes the Tri-Service short-term chemical standards from TB MED 577, derived for exposure duration of 7 days or less. These short-term standards apply in deployment situations in which units operate for 7 consecutive days or less when Army-produced drinking water, meeting the Tri-Service long-term standards, are not accessible. The short-term standards were developed to protect deployed military personnel from performance-degrading effects resulting from ingestion of field water supplies. Short-term dose-response and risk information for individual contaminants for ranges of concentrations above the Tri-Service Standards can be found in TB MED 577.

The quality of drinking water provided by any military personnel in a North Atlantic Treaty Organization (NATO) operation should, by treaty, comply with NATO short-term field drinking water standards [Standardization Agreements (STANAG)]. The U.S. Tri-Service short-term standards are equal to, or more stringent than, the STANAG standards.

The quality of field drinking water provided by the military forces of the U.S., Britain, Canada, and Australia in operations involving those nations should, by treaty, comply with the short-term

standards [Quadripartite Standardization Agreement (QSTAG)] of the Quadripartite Armed Forces. The U.S. Tri-Service standards are equal to or more stringent than the QSTAG standards.

Commercially procured bottled water should be considered safe for short-term field consumption if it is from a DOD-approved bottled water supplier. Drinking water produced and packaged by DOD should generally be considered safe for short-term field consumption if it is from a medically approved, properly operating DOD Reverse Osmosis Water Purification Unit (ROWPU). For use of host nation water supplies, the guidelines discussed elsewhere in Section 5 are applicable, as appropriate, for short-term consumption.

5.5 Taste and Odor Thresholds

Tastes and odors can indicate the presence of undesirable contaminants in field drinking water supplies. Industrial chemicals, naturally occurring compounds, and the by-products from reactions of chlorine disinfectants with industrial and naturally occurring chemicals can all produce objectionable tastes and odors. Such tastes and odors can be "flags" for Preventive Medicine and Quartermaster water supply personnel to initiate specific testing and monitoring as well as to initiate changes in water sources, treatment, storage, and distribution. Some of the chemicals that can produce tastes and odors in water may have minimal health effects; some can have direct adverse health consequences if present in sufficient concentrations at or above their taste or odor threshold, while others may produce adverse effects below their taste or odor threshold. Other taste and odor-producing chemicals, while presenting no significant health risks, make water supplies less palatable. Poor water palatability can contribute to dehydration casualties when personnel drink less water because of objectionable tastes or odors. Finally, some chemicals that can cause significant health effects impart little or no taste or odor in drinking water.

Taste and odor thresholds for chemicals in drinking water are shown in Appendix D when available. Because taste and odor thresholds do not always correlate with concentrations that cause toxic effects, this information is of limited use in assessing health risks posed by drinking water contaminants. Therefore, taste and odors should never be used alone to assess the quality of a drinking water supply. The primary sources for taste and odor threshold information for chemicals in water are the EPA Health Advisories for the individual compounds and the National Library of Medicine's Hazardous Substances Databank (HSDB). The thresholds in Appendix D are primarily individual data points. A range of concentrations was given when more than one data point was found.

5.6 Compounds Formed as a Result of Chlorine Disinfection of Field Water Supplies.

The Army disinfects field water supplies with chlorine in the form of hypochlorite. Chlorine may react with natural organic matter [such as decaying plant acids (to form trihalomethanes)] which the EPA considers to be carcinogenic. The standard Army ROWPU adequately removes natural organic matter. Chlorine disinfectant may also react with some industrial organic chemicals (e.g., acetone) which are poorly removed by the ROWPU, possibly producing toxic disinfection by-products. Information concerning removal of salts and organic materials from a water source by the ROWPU system is discussed in Appendix F.

Some common industrial contaminants of water (e.g., ammonia, 2-chlorophenol, and phenol) react with chlorine disinfectant to produce strong medicinal or other unpleasant tastes and odors. Such products, while not toxic at concentrations which produce objectionable tastes and odors, can cause deployed military defense personnel to refuse to drink from the approved field water supply or to seek an unapproved or higher risk source of drinking water. Compounds which form unpleasant chlorine disinfection by-products are annotated in the "Notes" column of Appendix D.

5.7 Estimating Severity of Effects

The "Notes" column of Appendix D shows the dose levels for some compounds that cause *minimal*, *significant*, *severe*, or *fatal* (catastrophic) effects in humans. (The water concentration in the "Notes" column are for water consumption rates of 5 L/day). They can be converted to consumption rates of 15 L/day by dividing by 3. These data may be useful in assessing the degree of risk from exceeding the MWGs-S for these compounds. However, human dose-effect levels are only available for a fraction of the compounds in Appendix D. The majority of the MWGs-S represent no-effect levels extrapolated from animal data. Due to the limited database and focus on no-effect levels, it is extremely difficult to estimate drinking water concentrations or doses that may cause effects at different levels of severity.

For compounds lacking data concerning the severity of effects at concentrations that exceed the MWGs-S, it may be most prudent to use bottled water or ROWPU-purified water if the MWG-S is exceeded. Nonetheless, there are some general principles that can be applied to estimate the potential severity of the risk for compounds exceeding the MWGs-S listed in Appendix D. These general principles are discussed below. Specific examples demonstrating an application of these principles are included in Appendix E, *Data Evaluation Examples,* Scenario 4.

TB MED 577 Standards: Since there is no margin of safety built into the standards for compounds covered by TB MED 577, the risk of severe performance-degrading effects increases as the concentrations in drinking water increase above the respective standards. In fact, for some compounds included in TB MED577, exposure to water concentrations even slightly higher than the TB MED standards can have serious effects. For example, with the nerve agents, the severity of the toxic response increases rapidly with the dose (i.e., the dose-response curve is very steep). Therefore, a small increase in the concentration above the standard estimated to cause only minimal effects could be debilitating. Thus, every effort should be made to avoid water sources which exceed the TB MED 577 standards.

5.8 Other MWGs-S

Minimal to Moderate Risk: EPA Health Advisories and ATSDR MRLs incorporate a UF of 10 to address the variability in response among more sensitive exposed persons including infants, young children, and the elderly. Therefore, most of the military health services personnel exposed to values as great as ten times higher than the guidelines should not experience substantial adverse health effects. For these chemicals, the MWGs-S can probably be exceeded by a factor of 10 in emergency situations without experiencing debilitating toxic effects (i.e. may be minimal to moderate level of risk). However, because of the sparsity of data, it would still be most prudent to attempt to obtain bottled water or ROWPU-purified water should concentrations exceed the MWGs-S.

Severe and Catastrophic Risks: Lethal human doses are given for a number of compounds listed in Appendix D. These doses are derived from estimates of single oral doses consumed in cases of human suicides or accidental poisonings. The estimates of the actual doses consumed are in most cases quite rough and in many cases may overestimate the actual amount that would be lethal. However, this information may be useful in identifying health risks that are potentially severe/catastrophic.

SECTION 6 - NONPOTABLE WATER

Nonpotable water is water that does not meet the military drinking water quality standards. Nonpotable water is not intended or approved for drinking or food preparation. Water may be determined to be nonpotable for health reasons or for reasons of palatability (e.g., the objectionable taste of sea water). Current DA doctrine (see TB MED 577) requires potable water (water that meets the military drinking water standards) for drinking; medical treatment; food preparation; ice production for food preservation and cooling; mess operations such as food washing; personal hygiene, such as shaving, brushing teeth, and helmet baths; and drinking water hose and pipeline testing and flushing. Army doctrine does permit the use of disinfected nonpotable fresh water for centralized hygiene, such as field showers, personnel decontamination, retrograde cargo washing, heat casualty cooling, mortuary affairs, and well development. Nonpotable fresh water (without disinfection) may only be used for well drilling, field laundry, pest control, and aircraft washing.

No useful public health criteria exist for assessing potential health risks from contaminated, nonpotable water, except for some limited guidelines for recreational waters. Deliberate contamination of nonpotable water supplies, or contamination from industrial operations can introduce a variety of chemicals and pathogens into water sources. Water containing these chemicals and pathogens can produce a variety of adverse effects ranging from irritations and infections to more serious toxic reactions depending on the extent of bodily contact with such waters. If there is substantial risk of ingestion or significant body contact with nonpotable water known or suspected of being heavily contaminated with chemicals or microorganisms, then military health services personnel should consider alternate water sources, disinfection, and/or personal protective items.

SECTION 7 – SOIL

Under most reasonable circumstances encountered in the field, there is negligible concern about acute health hazards which may impact mission success that are posed by exposures to contaminants in the soil. Exceptions may occur at specific industrial locations where buried or spilled materials may be encountered via excavation or similar activities. However, such sites should be readily identified prior to deployment or through visible inspection and contact with suspect areas or materials should be avoided. For short-term exposures to soil, therefore, the primary exposure of concern would be through direct dermal contact which can be generally minimized or avoided. Other exposures, however, may result from incidental ingestion and inhalation of dusts or particulates.

With respect to soil ingestion, it is unlikely for deployed military personnel to ingest quantities of soil sufficiently large enough to reach levels that may be acutely toxic. Soil ingestion is an incidental exposure in that it occurs in association with certain habits or behaviors. As a result, only small amounts are ingested over time. For example, a person may ingest soil and dust particles that adhere to food or cigarettes. Although cases of deliberate soil ingestion have been noted, these incidences have only been recorded in children.

Inhalation can be a potential concern, particularly in certain dusty environments and when strenuous activity is involved (thus increasing the inhalation rate). This exposure, however, would generally not be expected to produce significant health effects after only short-duration exposures. As discussed previously in Section 4.4, health effects associated with particulate matter, which are in part derived from dust and dirt, may decrease overall military personnel performance through respiratory irritation or inflammation.

In conclusion, potential health impacts resulting from exposure via ingestion, inhalation, and/or absorption of contaminants in soils would, more appropriately, fall into the category of long-term health effects which will be assessed in USACHPPM TG 230B.

APPENDIX A

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APPENDIX B

GLOSSARY

TERMS

Acidosis
Decrease of alkali in the blood, which may result in a decrease in the pH. Symptoms include very deep respirations, dehydration, drowsiness, stupor, or coma.

Anorexia
Loss of appetite.

Anoxia
Deficiency of oxygen.

Anuria
Complete urinary suppression or failure of kidney function.

Ataxia
Inability to coordinate muscles in movement.

Azotemia
An excess of urea and other nitrogenous waste in the blood resulting from kidney damage or failure.

Blepharospasm
A twitching or spasmodic contraction of eye.

Bradycardia
Abnormally slow heartbeat.

Cachexia
A state of ill health, malnutrition and wasting.

Cardiac Arrhythmia
Irregular heartbeat.

Cardiac Ischemia
Abnormally low flow of blood to the heart due to mechanical obstruction of an artery supplying blood to the area.

Chloracne
Acne-like facial disruptions resulting from repeated exposure to certain chlorinated hydrocarbons such as dioxins.

Cholestasis
Blockage of the flow of bile resulting in increases of bilirubin in the blood.

Cyanosis
Bluish discoloration of the skin resulting from deficient oxygen in the blood.

Desquamation
Shedding of outer layer of skin.

Dysphagia
Difficulty in swallowing.

Dysphonia
Difficulty in speaking; hoarseness.

Epigastric
Refers to the upper central portion of the abdomen between the lower ribs and the umbilicus (belly button).

Epistaxis
Nose bleed.

Erythemia
Redness of the skin.

Gastroenteritis
Inflammation of the stomach and intestines, usually accompanied by vomiting and diarrhea.

Hematuria
Blood in the urine.

Hemoglobinuria
The presence of hemoglobin the urine.

Hemolytic Anemia
Abnormal destruction of red blood cells resulting in a decrease in their number in the blood.

Hemoptysis
Spitting of blood arising from hemorrhage of the larnyx, trachea, bronchial tubes, or lungs.

Hyperplasia
Abnormal but non-cancerous increase in the number of cells in a tissue or organ.

Hypertension
Elevated blood pressure.

Hyperthermia
Elevated body temperature.

Hypotension
Reduced blood pressure.

Hypothermia
Decreased body temperature.

Hypoxemia
Insufficient oxygenation of the blood.

Immunosuppression
Suppression of the immunologic response, leading to decreased resistance to disease.

Jaundice
A yellow staining or darkening of the skin, whites of the eyes, and excreta due to abnormal processing of bile by the liver.

Lassitude
Lethargy, apathy, exhaustion.

Leukopenia
Reduction in number of circulating white blood cells (the cells which fight infection).

Malaise
Discomfort, uneasiness indicative of infection.

Methemoglobinemia
Condition in which the oxidation state of iron in hemoglobin is abnormal leading to decreased availability of oxygen to the body tissues.

Miosis
Contraction of the pupil (pin-pointed pupil).

Monocytosis
Excessive number of monocytes (a type of white blood cell) in the blood.

Mucosa
Mucous membrane; membrane lining bodily channels that communicate with air (i.e., mouth and respiratory tract); glands of mucous membranes secrete mucous.

Mydriasis
Dilation of the pupil.

Narcosis
Stupor or deep unconsciousness; can be caused by exposure to a number of chemicals. Differs from anesthesia which refers to the loss of sensation (e.g., pain) or touch and can be local or general.

Nephritis
Inflammation of the kidney.

Pallor
Paleness of the skin.

Palpitation
Perceptible irregular or rapid beating or pulsation of the heart.

Paresthesia
Burning prickling, tingling, or tickling sensation.

Paroxysmal
A sudden, periodic attack or recurrence of symptoms of a disease; an exacerbation of the symptoms of a disease.

Photophobia
Unusual intolerance to light.

Polyneuropathy
Disease involving a number of peripheral nerves (for example, nerves in the hands, feet or legs).

Porphyria Cutanea Tarda
A metabolic disorder in which reddish pigments or porphyrins are produced in the liver. The excess pigments accumulate in the skin where they are activated by visible light which causes photosensitive skin reactions characterized by skin erosions and blistering. These painful sores resolve slowly and may result in scarring, hair loss, and skin atrophy. Excess porphyrins are excreted in the urine which becomes colored dark red or brown as a result.

Precordial
Pertaining to the region over the pit of the stomach.

Prostration
Marked loss of strength; exhaustion.

Pulmonary Edema
Buildup of fluid in the lung.

Retrosternal
Behind the sternum.

Spasticity
Hypertension of muscles causing stiff and awkward movements.

Spermatogenesis
Development of sperm cells.

Stenosis
Construction or narrowing of a passage or orifice.

Syncope
A transient form of unconsciousness during which the person slumps to the ground resulting from cerebral anoxia (insufficient oxygen in the brain).

Tachycardia
Excessively rapid heartbeat.

Tinnitus
Noise (typically ringing) in the ears.

Urogenital tract
Denotes the organs involved in reproduction and urination.

Ventricular Fibrillation
Rapid contractions or twitching of the muscle fibers that replace normal contraction of the ventricular chambers of the heart.

Vertigo
Dizziness; sense of spinning.

Vesiculation
Formation of a small blister-like small elevation on the skin containing serous fluid.

ACRONYMS

ACGIH	American Conference of Governmental Industrial Hygienists
AEGLs	Acute Exposure Guideline Levels
AFOSH	Air Force Occupational Safety and Health
AIHA	American Industrial Hygiene Association
ATSDR	Agency for Toxic Substances and Disease Registry
CAS	Chemical Abstracts Service
CAWG	Chemical Agent Working Group
CEGLs	Continuous Exposure Guidance Levels
CNS	Central Nervous System
DNBI	Disease and Non-Battle Injury
DOD	Department of Defense
DOE	Department of Energy
EEGLs	Emergency Exposure Guidance Levels
EPA	Environmental Protection Agency
gm	gram
g/kg	gram per kilogram
gm/L	gram per Liter
HSDB	Hazardous Substance Databank
IDLH	Immediately Dangerous to Life and Health
LD	Lethal Dose
LD_{50}	Lethal Dose 50%

L/day	Liter per day
m	meter
MAF	Military Adjustment Factor
MAGs-S	Military Air Guidelines-Short Term
MCLGs	Maximum Contaminant Level Goals
MCLs	Maximum Contaminant Levels
µg/kg	microgram per kilogram
mg/kg	milligram per kilogram
mg/kg/day	milligram per kilogram per day
mg/L	milligram per Liter
mg/m	milligram per meter
mg/m^3	milligram per cubic meter
MRLs	Minimum Risk Levels
MWGs-S	Military Water Guidelines-Short Term
NA	Not applicable
NAAQS	National Ambient Air Quality Standards
NAC	National Advisory Committee
NATO	North Atlantic Treaty Organization
ND	Not determined
NIOSH	National Institute of Safety and Occupational Health
NOAEL	No-Observed Adverse Effect Level
NRC	National Research Council
ppm	parts per million

QSTAG	Quadripartite Standardization Agreement
ROWPU	Reverse Osmosis Water Purification Unit
STANAG	Standardization Agreement
TB MED	Technical Bulletin, Medical
TEELs	Temporary Emergency Exposure Limits
TG	Technical Guide
TLVs	Threshold Limit Values
TT	Treatment Technique
TWA	Time-Weighted Average
UF	Uncertainty Factor
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
WQAS-PM	Water Quality Analysis Set-Preventive Medicine

APPENDIX C

MILITARY AIR GUIDELINES – SHORT TERM (MAGs-S) TABLE

GROUPED LISTING OF CHEMICALS

The following groups of compounds are provided for quick reference. Groups include various chemical categories as well as some general "prioritization" of compounds which are of significant toxicity and are deemed somewhat widespread in use/production contamination. These groups are for general consideration only. Decisions on sampling should be based on a site-specific evaluation.

Chemical Warfare Agents

Military Smokes and Obscurants

Riot Control Agents

Particulates

High Priority

Medium Priority

Low Priority

Common Operational Volatiles

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms^{‡N}	Target Organ^N	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Acetone Cyanohydrin 75-86-5	**4.7**^{C} (16.4)	**ND**	**ND**	**4.7**^{C} (16.4)	Irritation eyes, skin, respiratory system; dizziness, weakness, headache, confusion, convulsions; liver, kidney injury; pulmonary edema, asphyxia.	Eyes, skin, respiratory system, central nervous system, cardiovascular system, liver, kidneys, gastrointestinal tract		
Acrolein 107-02-8	**0.1** (0.23)	**0.5** (1.15)	**3.0** (6.9)	**0.01** (0.023)	Irritation eyes, skin, mucous membrane; decreased pulmonary function; delayed pulmonary edema; chronic respiratory disease.	Eyes, skin, respiratory system, heart	**0.022 – 1.8**	Pungent odor; concentrations of 0.06 ppm for 5 min caused irritation in humans.
Acrylonitrile 107-13-1	**10** (22)	**35** (76)	**75** (163)	**0.10** (0.22)	Irritation eyes, skin; asphyxia; headache; sneezing; nausea, vomiting; weakness, lightheadedness; skin vesiculation; scaling dermatitis.	Eyes, skin, cardiovascular system, liver, kidneys, CNS	**17**	Potential occupational carcinogen.
Aldrin 309-00-2	**ND**	**ND**	(25)	(0.25^S)	Headache, dizziness; nausea, vomiting, malaise; limb jerks; convulsions; coma; hematuria: azotemia.	CNS, liver, kidneys, skin	(0.25)	Dermal exposures may contribute to total dose; potential occupational carcinogen.
Allyl alcohol 107-18-6	**4** (9.5)	**15** (36)	**20** (48)	**2**^{S} (0.48)	Eye irritation, tissue damage; irritation upper respiratory system, skin; pulmonary edema.	Eyes, skin, respiratory system	**1.4 – 2.1**	Pungent, mustard-like odor. Dermal exposures may contribute to total dose.
Ammonia 7664-41-7	**25** (17)	**200** (139)	**1000** (696)	**0.5** (0.35)	Irritation eyes, nose, throat; difficulty breathing, bronchospasm; pulmonary edema; pink frothy sputum; skin burns.	Eyes, skin, respiratory system	**17**	Pungent, suffocating odor.

***Notes for table on page C-22**

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms^{‡N}	Target Organ^N	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Arsenic trichloride 7784-34-1	**ND**	**ND**	**ND**	(0.01)	Irritation of nose and throat^R.	Eyes, respiratory system, mucous membranes^R		1-14 day value based on inorganic arsenic.
Arsine 7784-42-1	**NA**	**0.5** (1.6)	**1.5** (4.8)	**0.005** (0.016)	Headache, malaise; difficulty breathing; nausea, vomiting; bronze skin; hematuria; jaundice.	Blood, liver, kidneys	**0.5**	Disagreeable, garlic-like odor.
Benzene 71-43-2	**50** (160)	**150** (479)	**1000** (3195)	**0.05** (0.16)	Irritation eyes, skin, nose, respiratory system; giddiness; headache, nausea, staggered gait; fatigue, loss of appetite, lassitude (weakness, exhaustion); dermatitis; bone marrow depressant/depression.	Eyes, skin, respiratory system, blood, CNS, bone marrow	**34 - 119**	Aromatic odor; chronic exposures to low concentrations causes bone marrow depression; potential occupational carcinogen.
Boron tribromide 10294-33-4	**1**^{C} (10)	**ND**	**ND**	**1**^{C} (10)	Irritation eyes, skin, respiratory system; dyspnea, pulmonary edema.	Eyes, skin, respiratory system		
Boron trifluoride 7637-07-2	**0.72** (2.0)	**11** (30)	**36** (100)	**1**^{C} (2.8)	Irritation eyes, skin, nose, respiratory system; epistaxis (nosebleed); eye, skin burns; pneumonia; kidney damage.	Eyes, skin, respiratory system, kidneys		Low 1-hr value based on NOAEL; 6-hr exposures to rats at 2.2 ppm 6hrs/d for 3 months produced slight signs of irritation.
Bromine 7726-95-6	**0.2** (1.3)	**1** (6.5)	**5** (33)	**0.1** (0.65)	Dizziness, headache; lacrimation, epistaxis; cough, pulmonary edema, pneumonia; abdominal pain, diarrhea; measle-like eruptions; eye, skin burns.	Respiratory system, eyes, CNS, skin	**0.05**	Suffocating odor; concentrations above 10 ppm causes severe upper respiratory irritation; 1.7 – 3.5 ppm produces severe choking; 30 ppm would be fatal in a short duration.
Bromine pentafluoride 7789-30-2	**ND**	**ND**	**ND**	**0.1** (0.72)	Irritation eyes, skin, respiratory system; corneal necrosis; skin burns; difficulty breathing, pulmonary edema; liver, kidney injury.	Eyes, skin, respiratory system, liver, kidneys		Potential sensitizer.

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms[‡N]	Target Organ[N]	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Butyl isocyanate (n-) 111-36-4	**0.01** (0.04)	**0.05** (0.2)	**1** (4.1)	**ND**	Skin irritation, eczema, conjunctivitis[H].	Skin and eyes[H]		Concentrations of 0.1 – 1 ppm produce irritation to the respiratory tract and mucous membranes.
Carbon disulfide 75-15-0	**1** (3.1)	**50** (156)	**500** (1557)	**1**[S] (3.1)	Dizziness, headache, nervousness, loss of appetite, polyneuropathy, ocular changes, coronary heart disease, gastritis, kidney, liver injury, dermatitis, reproductive effects.	CNS, peripheral nervous system, cardiovascular system, eyes, kidneys, liver, skin, reproductive system	**0.11**	Dermal exposures may contribute to total dose; sweet, ether-like odor.
Carbon monoxide 630-08-0	**200** (229)	**350** (286)	**500** (572)	**2.5** (2.9)	Headache, rapid breathing, nausea, weakness, dizziness, confusion, hallucinations; cyanosis; depressant/depression S-T segment of electro-cardiogram, angina, syncope.	Cardiovascular system, lungs, blood, CNS		
Carbon tetrachloride 56-23-5	**20** (126)	**100** (629)	**750** (4719)	**0.2** (1.3)	Irritation eyes, skin; CNS depressant/depression; nausea, vomiting; liver, kidney injury; drowsiness, dizziness, incoordination.	CNS, eyes, lungs, liver, kidneys, skin.	**140 - 584**	Aromatic, ether-like odor; potential occupational carcinogen.
Carbonyl fluoride 353-50-4	**ND**	**ND**	**ND**	**0.2** (0.54)	Irritation eyes, skin, mucous membrane, respiratory system; eye, skin burns; excessive tearing; cough, pulmonary edema, difficulty breathing.	Eyes, skin, respiratory system, bone		
Chlorine 7782-50-5	**1** (2.9)	**3** (8.7)	**20** (58)	**0.1** (0.29)	Burning of eyes, nose, mouth; excessive tearing, rhinorrhea; coughing, choking, substernal pain; nausea, vomiting; hypoxemia; dermatitis.	CNS, eyes, lungs, liver, kidney, skin	**0.02 – 3.4**	Pungent, disagreeable odor; a concentration of 34 – 51 ppm has been reported to be fatal in 1 – 1.5 hours.
Chlorine trifluoride 7790-91-2	**0.1** (0.4)	**1** (3.8)	**10** (38)	**0.1**[C] (0.4)	Respiratory irritation; in animals: excessive tearing, corneal ulcer; pulmonary edema.	Skin, eyes, respiratory system		

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms[‡N]	Target Organ[N]	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Chloroacetaldehyde 107-20-0	**1**[C] (3.2)	**22** (71)	**45** (144)	**1**[C] (3.2)	Irritation skin, eyes, mucous membrane; skin burns; eye damage; pulmonary edema; skin, respiratory system sensitization.	Eyes, skin, respiratory system		Volunteers found that concentrations of 45 ppm were very disagreeable and conjunctival irritation was noted.
Chloroacetone 78-95-5	**1**[C] (3.8)	**ND**	**ND**	**1**[C] (3.8)	Excessive tearing, irritation skin and respiratory tract, pulmonary edema[H].	Eyes, skin, respiratory tract[H]		Concentration of 605 ppm is lethal after a 10 minute exposure and 26 ppm is intolerable after a 1 minute exposure.
Chloroacetophenone [CN] 532-27-4	**ND**	**ND**	(15)	**0.05** (0.32)	Excessive tearing, irritation of the skin, rashes in tender skin areas of the armpits, knees, elbows, area of the crotch and buttocks[T].	Skin, eyes[T]	**0.016**	Floral to sharp and irritation odor with increasing concentration; concentration of 31 mg/m^3 is intolerable after 3 minutes.
Chloroacetyl chloride 79-04-9	**0.1** (0.46)	**1** (4.6)	**10** (46)	**0.05**[S] (0.23)	Irritation eyes, skin, respiratory system; eye, skin burns; cough, wheezing, difficulty breathing; excessive tearing.	Eyes, skin, respiratory system		Dermal exposures may contribute to total dose.
Chlorobenzylidene malonitrile o- [CS] 2698-41-1	**0.05**[C] (0.39)	**ND**	**0.26** (2)	**0.05**[C] (0.39)	Extremely irritating to the nose and throat with immediate lacrimatory effects; nausea and vomiting; shortness of breath, burning of the skin especially effecting the eyes, nose, mouth, and tender areas around the knees, elbows, crotch, and buttocks[T].	Eyes, skin, CNS, respiratory system[T]		Peppery odor; incapacitating concentration range from 12 – 20 mg/m^3 after 20 seconds of exposure.
Chloroform 67-66-3	**NA**	**50** (244)	**5000** **(**24,400)	**0.1** (0.5)	Irritation eyes, skin; dizziness, mental dullness, nausea, confusion; headache, fatigue; anesthesia; enlarged liver.	Liver, kidneys, heart, eyes, skin, CNS.	**133 - 276**	Pleasant, ether-like odor; potential occupational carcinogen; disorientation occurs at concentrations exceeding 1000 ppm.

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms[‡N]	Target Organ[N]	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Crotonaldehyde 4170-30-3	**2** (5.7)	**10** (28.6)	**50** (143)	**0.3**[CS] (0.86)	Irritation eyes, respiratory system; in animals: difficulty breathing, pulmonary edema, irritation skin.	Eyes, skin, respiratory system	**0.11**	Dermal exposures may contribute to total dose; pungent odor.
Cyanogen 460-19-5	**30** (64)	**50** (107)	**50** (107)	**1** (2.1)	Irritation eyes, nose, upper respiratory system; excessive tearing; cherry red lips, bradycardia; headache, vertigo, convulsions; dizziness, loss of appetite, weight loss.	Eyes, respiratory system, CNS, cardiovascular system	**235**	
Diborane 19287-45-7	**0.3** (0.34)	**1** (1.13)	**3** (3.4)	**0.01** (0.011)	Chest tightness, precordial pain, shortness breathing, cough, nausea, headache, dizziness, fever, fatigue, weakness, tremor; liver, kidney damage, pulmonary edema and hemorrhage.	Respiratory system, CNS, liver, kidneys	**2.5**	Repulsive, sickly sweet odor.
Dichloroethane (1,1-) 75-34-3	**ND**	**ND**	**3000** (12,144)	**10** (41)	Irritation skin; CNS depressant/ depression; liver, kidney, lung damage.	Skin, liver, kidneys, lungs, CNS	**100 – 200**	Odor threshold range broad: care should be used when attempting to estimate exposure from odor perception.
Dieldrin 60-57-1	(0.75)	(1.25)	(50)	(0.025[S])	Headache, dizziness; nausea, vomiting, malaise, sweating; limb jerks; convulsions; coma; in animals: liver, kidney damage.	CNS, liver, kidneys, skin		Dermal exposures may contribute to total dose; potential occupational carcinogen.
Diesel fuel smoke	(8)	(80)	**ND**	(5)	Inflammation of lung, irritation of respiratory tract, congestion in nasal turbinate, bronchopneumonia, bronchitis, pulmonary congestion with edema and hemorrhage[M].	Lung, respiratory tract[M]		
Diketene 674-82-8	**1** (3.4)	**5** (17)	**50** (172)	**NA**	Eye, skin, and respiratory tract irritation[H].	Eyes, skin, respiratory tract[H]		

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms[‡N]	Target Organ[N]	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Dimethyl sulfate 77-78-1	**0.3** (1.5)	**1** (5.2)	**7** (36)	**0.01[S]** (0.05)	Irritation eyes, nose; headache, giddiness; conjunctivitis; photophobia, edema; dysphonia, dysphagia, productive cough; chest pain; difficulty breathing, cyanosis; vomiting, diarrhea.	Eyes, skin, respiratory system, liver, kidneys, CNS		Dermal exposure may contribute to total dose.
Endrin 72-20-8	(0.3)	(2)	(2)	(0.01[S])	Epileptiform convulsions; stupor, headache, dizziness; abdominal discomfort, nausea, vomiting; insomnia; aggressiveness, confusion; lethargy (drowsiness or indifference), weakness; loss of appetite; in animals: liver damage.	CNS, liver	(0.28)	Dermal exposures may contribute to total dose.
Ethyl benzene 100-41-4	**125** (542)	**125** (542)	**800** (3474)	**10** (43)	Irritation eyes, skin, mucous membrane; headache; dermatitis; narcosis, coma.	Eyes, skin, respiratory, CNS	**0.09 – 0.60**	Aromatic odor.
Ethylenimine 151-56-4	**1.5** (2.64)	**2.3** (4.0)	**100** (176)	**0.05[S]** (0.09)	Irritation eyes, skin, nose, throat; nausea, vomiting; headache, dizziness; pulmonary edema; liver, kidney damage; eye burns; skin sensitization.	Eyes, skin, respiratory system, liver, kidneys		Dermal exposures may contribute to total dose; ammonia-like odor.
Ethylene oxide 75-21-8	**7.5** (14)	**50** (90)	**500** (900)	**0.1** (0.18)	Irritation eyes, skin, nose, throat; peculiar taste; headache, nausea; vomiting, diarrhea; difficulty breathing, cyanosis, pulmonary edema; incoordination; EKG abnormalities.	Eyes, skin, respiratory system, liver, CNS, blood, kidneys, reproductive system	**425**	Based on soluble tungsten; sweet olefininc odor; concentrations > 1 hr, at 2000 ppm may be fatal.

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms[‡N]	Target Organ[N]	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Fluorine 7782-41-4	♦	**5** (7.8)	**20** (31)	**1** (1.6)	Irritation eyes, nose, respiratory system; laryngeal spasm, bronchitis spasm; pulmonary edema; eye, skin burns; liver and kidney damage in animals.	Eyes, skin, respiratory system, liver, kidneys	**0.14**	Low value based on odor; repeated exposure to 10 ppm was reported to be well-tolerated in workers; concentrations of 25 ppm have been tolerated briefly, yet two volunteers developed sore throats and chest pains that lasted 6 hrs; 50 ppm could not be tolerated.
Fog oil smoke	(9)	(90)	**ND**	(5)	Mild erythema, inflammation, dermatitis, acne, eczema, and contact sensitivity; pneumonia, cough, and phlegm[M].	Skin, lungs, respiratory system[M]		
Formaldehyde 50-00-0	**1** (1.2)	**10** (12.3)	**25** (31)	**0.3**[C] (0.37)	Respiratory system irritation; excessive tearing; cough, bronchitis spasm.	Eyes, respiratory system	**0.83**	Pungent, suffocating odor.
GA **(Tabun)** 77-81-6	(0.01)	**ND**	(0.1)	(0.00001)	Running nose; tightness of chest; dim vision; difficulty breathing; drooling and excessive sweating; nausea, vomiting; CNS effects[H].	Respiratory system, CNS[H]		Values based on anti-chlolinesterase activity; miosis for 1-hour values. 1–hr = Ct; 1-14 day = TWA (8 hr)/10.
GB **(Sarin)** 107-44-8	(0.008)	**ND**	(0.1)	(0.00001)	Running nose; tightness of chest; dimness of vision and miosis; difficulty in breathing; drooling and excessive sweating; nausea, vomiting; cramps and involuntary defecation or urination; twitching, jerking, and staggering; headache, confusion, drowsiness, coma, and convulsion; cessation of breathing and death[H].	Respiratory system, CNS, gastrointestinal system[H]		Values based on anti-chlolinesterase activity; miosis for 1-hour values. 1-hr = Ct;1-14 day = TWA (8 hr)/10.
GD **(Soman)** 96-64-0	(0.003)	**NA**	(0.05)	(0.000003)	See GB.	Respiratory system, CNS, gastrointestinal system[H]		Values based on anti-chlolinesterase activity; miosis for Low 1-hour values. 1-hr = C; 1-14 day – TWA (8 hr)/10.

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms[‡N]	Target Organ[N]	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Hexachlorobutadiene 87-68-3	**3** (32)	**10** (107)	**30** (320)	**0.002**[S] (0.02)	In animals: irritation eyes, skin, respiratory system; kidney damage.	Eyes, skin, respiratory system, kidneys	**1.1**	Dermal exposures may contribute to total dose; turpentine-like odor; potential occupational carcinogen; concentrations of 23 ppm (245 mg/m^3) produced strong odors; 1 ppm (10 mg/m^3), faint odor.
Hexachlorocyclopentadiene 77-47-4	**0.02** (0.22)	**0.02** (0.22)	**0.02** (0.22)	**0.01** (0.11)	Irritation eyes, skin, respiratory system; excessive tearing; sneezing, cough, difficulty breathing, salivation, pulmonary edema; nausea, vomiting, diarrhea.	Eyes, skin, respiratory system, liver, kidneys in animals	**0.03**	Pungent, unpleasant odor.
Hexachloroethane smoke 67-72-1	(0.3)	(3)	**ND**	(0.2)	Acute respiratory distress syndrome, edema, difficulty breathing, chest constriction, retrosternal pain, hoarseness, cough, lacrimation expectoration, and occasional hemoptysis; irritation of the nose, throat, and chest; nausea[M].	Respiratory tract, lung, eye[M]		Symptoms and target organ based on exposure to $ZnCl_2$, a component released when the bomb is ignited.
Hexane 110-54-3	**150** (528)	**250** (880)	**1100** (3872)	**5**[S] (18)	Irritation eyes, nose; lightheadedness; nausea, headache; peripheral neuropathy: numbness extremities, muscle weakness; dermatitis; giddiness; chemical pneumonia (aspiration liquid).	Eyes, skin, respiratory system, CNS, peripheral nervous system	**130**	Dermal exposures may contribute to total dose.
Hydrazine 302-01-2	**0.3** (0.4)	**0.8** (1)	**10** (13)	**0.01** (0.013)	Irritation eyes, skin, nose, throat; temporary blindness; dizziness, nausea; dermatitis; eye, skin burns; in animals: bronchitis, pulmonary edema; liver, kidney damage; convulsions.	Eyes, skin, respiratory system, CNS, liver, kidneys	**3 - 4**	Potential carcinogen.
Hydrogen bromide 10035-10-6	**3** (9.9)	**3** (9.9)	**30** (99)	**3**[C] (9.9)	Irritation eyes, skin, nose, throat.	Eyes, skin, respiratory system	**2**	Sharp irritating odor.

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms[‡N]	Target Organ[N]	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Hydrogen chloride 7647-01-0	♦	**20** (30)	**150** (223)	**5**[C] (7.5)	Irritation nose, throat, larynx; cough, choking; dermatitis.	Eyes, skin, respiratory system	**0.77**	Asthmatics may experience adverse effects above 3 ppm; concentrations of 35 ppm caused throat irritation; 50 – 100 ppm are barely tolerable.
Hydrogen cyanide 74-90-8	**4.7** (5.2)	**10** (11)	**25** (27)	**0.05**[S] (0.05)	Asphyxia; weakness, headache, confusion; nausea, vomiting; increased rate and depth of respiration or respiration slow and gasping; thyroid, blood changes.	CNS, cardiovascular system, thyroid, blood		Dermal exposures may contribute to total dose; sweetish, almond-like odor; concentrations of 45 – 54 ppm may be tolerable for 0.5 – 1.0 hr; 110 – 135 ppm may be fatal after 0.5 – 1.0 hr or later.
Hydrogen fluoride 7664-39-3	♦	**20** (16.4)	**50** (41)	**3**[C] (2.4)	Irritation eyes, skin, nose, throat; pulmonary edema; eye, skin burns; rhinitis; bronchitis; bone changes.	Eyes, skin, respiratory system, bones	**0.04**	Exposures of 2.7-4.7 ppm produced very slight irritation and was tolerated 6hrs/d for several days; concentrations of 50 ppm for 30 – 60 min may be fatal. volunteers tolerated 4.7 ppm for 6-hrs/ day for 10 – 50 days.
Hydrogen selenide 7783-07-5	**ND**	**ND**	**1** (3.3)	**0.05** (0.16)	Irritation eyes, nose, throat; nausea, vomiting, diarrhea; metallic taste, garlic breathing; dizziness, lassitude, fatigue.	Eyes, respiratory system, liver		
Hydrogen sulfide 7783-06-4	♦	**30** (42)	**100** (140)	**1** (1.4)	Irritation eyes, apnea, coma, convulsions; conjunctivitis, eye pain, lacrimation photophobia (abnormal visual intolerance to light), corneal vesiculation; dizziness, headache, fatigue, insomnia; gastrointestinal disturbance.	Eyes, respiratory system, CNS	**0.001 – 0.13**	Rotten egg odor strong at concentrations above 0.1 ppm; concentrations of 170 to 300 ppm are the maximum tolerated concentrations for 1-hr without serious consequences; olfactory fatigue occurs at 100 ppm.

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms^{‡N}	Target Organ^N	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Iron pentacarbonyl 13462-40-6	**ND**	**ND**	**ND**	**0.01** (0.08)	Irritation eyes, mucous membrane, respiratory system; headache, dizziness, nausea, vomiting; fever, cyanosis, difficulty breathing; liver, kidney, lung injury; degenerative changes in CNS.	Eyes, respiratory system, CNS, liver, kidneys		
Lewisite 541-25-3	**0.003**^{C}	**ND**	**ND**	(0.003^C)	Immediate pain in the eyes, resulting in profuse tearing and blepharospasm; pulmonary irritant, erythema, pulmonary edema^H.	Eyes, pulmonary system^H		
Lindane 58-89-9	(1.5)	(50)	(50)	(0.05^S)	Irritation eyes, skin, nose, throat; headache; nausea; convulsions; respiratory difficulty; cyanosis; aplastic anemia; muscle spasm; in animals: liver, kidney damage.	Eyes, skin, respiratory system, CNS, blood, liver, kidneys		Dermal exposures may contribute to total dose; 2 & 3 values based on oral data.
Methyl bromide 74-83-9	**15** (58.3)	**50** (195)	**200** (777)	**0.1**^{S} (0.38)	Irritation eyes, skin, muscle weakness, visual disturbance, dizziness; nausea, vomiting, headache; malaise; hand tremor; convulsions; difficulty breathing; skin vesiculation.	Eyes, skin, respiratory system, CNS		Dermal exposures may contribute to total dose.
Methylene chloride 75-09-2	**200** (695)	**750** (2600)	**4000** (13,880)	**0.4** (1.4)	Irritation eyes, skin; fatigue, weakness, somnolence (sleepiness, unnatural drowsiness), lightheadedness; numbness, limbs tingle, nausea.	Eyes, skin, cardiovascular system, CNS	**160**	Sweet, chloroform-like odor; potential occupational carcinogen.
Methyl hydrazine 60-34-4	**ND**	**ND**	**ND**	**0.001**^{S} (0.002)	Irritation eyes, skin, respiratory system; vomiting, diarrhea, tremor, ataxia; anoxia, cyanosis; convulsions.	Eyes, skin, respiratory system, CNS, liver, blood, cardiovascular system	**1.7**	Dermal exposures may contribute to total dose.
Methyl isocyanate 624-83-9	**0.025** (0.06)	**0.5** (1.17)	**5** (11.7)	**0.02**^{S} (0.05)	Irritation eyes, skin, nose, throat; respiratory sensitization, cough, pulmonary secretions, chest pain, difficulty breathing; asthma; eye, skin damage.	Eyes, skin, respiratory system	**2.1**	Dermal exposures may contribute to total dose; sharp, pungent odor.

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms[‡N]	Target Organ[N]	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Methyl mercaptan 74-93-1	♦	**25** (49)	**100** (197)	**0.05** (0.1)	Irritation eyes, skin, respiratory system; narcosis; cyanosis; convulsions.	Eyes, skin, respiratory system, CNS, blood	**0.0016**	Odor of rotten cabbage significant at concentrations above 0.005 ppm; odor fatigue occurs with time.
Nitric acid 7697-37-2	**0.5** (1.3)	**4** (10)	**13** (34)	**2** (5.2)	Irritation eyes, skin, mucous membrane; delayed pulmonary edema, pneumonititis, bronchitis; dental erosion.	Eyes, skin, respiratory system, teeth	**0.3**	
Nitric oxide 10102-43-9	**25** (31)	**25** (31)	**100** (123)	**2.5** (3.1)	Irritation eyes, wet skin, nose, throat; drowsiness, unconsciousness; methemoglobinemia.	Eyes, skin, respiratory system, blood, CNS	**0.3**	
Nitrogen dioxide 10102-44-0	♦	**15** (28)	**20** (38)	**3** (5.6)	Irritation eyes, nose, throat, cough, mucoid frothy sputum, decreased pulmonary function, difficulty breathing; chest pain; pulmonary edema, cyanosis, rapid breathing, tachycardia.	Eyes, respiratory system, cardiovascular system	**1.06**	
Paraquat 4685-14-7	(0.15)	(0.15)	(1.0)	(0.01)	Irritation eyes, skin, nose, throat, respiratory system; epistaxis; dermatitis; fingernail damage; irritation gastrointestinal tract; heart, liver, kidney damage.	Eyes, skin, respiratory system, heart, liver, kidneys, gastrointestinal tract		Toxicity based on particle size (see RD 230).
Parathion 56-38-2	(0.3)	(2)	(10)	(0.01)	Irritation eyes, skin, respiratory system; miosis; rhinorrhea; headache; chest tightness, wheezing, laryngeal spasm, salivation, cyanosis; anorexia, nausea, vomiting, abdominal cramps, diarrhea; sweating; muscle fasiculation, weakness, paralysis; giddiness, confusion, ataxia; convulsions, coma; low blood pressure; cardiac irregular/irregularities.	Eyes, skin, respiratory system, CNS, cardiovascular system, blood cholinesterase	**0.04**	

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms[‡N]	Target Organ[N]	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Perchloroethylene 127-18-4	**100** (678)	**200** (1356)	**1000** (6781)	**2.5** (17)	Irritation eyes, skin, nose, throat, respiratory system; nausea; flush face, neck; vertigo (an illusion of movement), dizziness, incoordination; headache, somnolence (sleepiness, unnatural drowsiness); skin erythema (skin redness); liver damage.	Eyes, skin, respiratory system, liver, kidneys, CNS	**47**	Mild chloroform-like odor; potential occupational carcinogen.
Perchloromethyl mercaptan 594-42-3	**ND**	**ND**	**10** (1.3)	**0.1** (0.76)	Irritation eyes, skin, nose, throat; lacrimation; cough, difficulty breathing, deep breathing pain, coarse rales; vomiting; pallor, tachycardia; acidosis; anuria; liver, kidney damage.	Eyes, skin, respiratory system, liver, kidneys	**0.001**	
Phosgene 75-44-5	**0.1** (0.4)	**0.2** (0.81)	**1** (4)	**0.01** (0.04)	Irritation eyes; dry burning throat; vomiting; cough, foamy sputum, difficulty breathing, chest pain, cyanosis.	Eyes, skin, respiratory system	**0.5**	Lethality may occur at lower (5 ppm) concentrations due to pulmonary edema.
Phosphine 7803-51-2	**NA**	**0.5** (0.7)	**5** (7)	**0.03** (0.04)	Nausea, vomiting, abdominal pain, diarrhea; thirst; chest tightness, difficulty breathing, muscle pain, chills; stupor or syncope; pulmonary edema.	CNS, respiratory system	**0.9**	Disagreeable odor of rotten fish or garlic; concentrations up to 35 ppm have caused diarrhea, nausea, vomiting, cough, headache, and dizziness.
White phosphorus (yellow) 7723-14-0	(0.3)	(3)	(5)	(0.01)	Irritation eyes, respiratory tract; eyes, skin burns; abdominal pain, nausea, jaundice; anemia; cachexia; dental pain, salivation, jaw pain, swelling.	Eyes, skin, respiratory system, liver, kidneys, jaw, teeth, blood		
Phosphorus oxychloride 10025-87-3	**ND**	**ND**	**ND**	**0.007** (0.06)	Irritation eyes, skin, respiratory system; eye, skin burns; difficulty breathing, cough, pulmonary edema; dizziness, headache, weakness; abdominal pain, nausea, vomiting; nephritis.	Eyes, skin, respiratory system, CNS, kidneys		

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms^{‡N}	Target Organ^N	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Phosphorus trichloride 7719-12-2	**ND**	**ND**	**25** (140)	**0.2** (1.1)	Irritation eyes, skin, nose, throat; pulmonary edema; eye, skin burns.	Eyes, skin, respiratory system		Concentrations of 1.8 – 27 ppm have been reported to produce burning of the eyes and throat, and mild bronchitis within 2 – 6 hrs after exposure.
Red phosphorus smoke	(1)	(10)	(1000)	(1)	Irritation eyes, respiratory tract; eye, skin burns; abdominal pain, nausea, jaundice; anemia; cachexia; dental pain, salivation, jaw pain, swelling.	Eyes, skin, respiratory system, liver, kidneys, jaw, teeth, blood		
Selenium hexafluoride 7783-79-1	**0.15** (1.2)	**0.25** (2)	**2** (16)	**0.05** (0.4)	Pulmonary irritation, edema.	Respiratory system		Based on animal data.
Stibine 7803-52-3	**ND**	**0.5** (2.6)	**1.5** (7.7)	**0.1** (0.51)	Headache, weakness; nausea, abdominal pain; lumbar pain, hemoglobinuria, hematuria, hemolytic anemia; jaundice; pulmonary irritation.	Blood, liver, kidneys, respiratory system		
Sulfur dioxide 7446-09-5	♦	**3** (8)	**15** (39)	**1** (2.6)	Irritation eyes, nose, throat; rhinorrhea (discharge of thin nasal mucus); choking, cough; reflex bronchoconstriction.	Eyes, skin, respiratory system	**1.1**	Metallic taste, sharp. Asthmatics may experience reduced airway resistance above 0.3 ppm.
Sulfur mustard [HD] 505-60-2	(0.42)	**ND**	**1.7**	(0.003^C)	Conjunctivitis, blindness, edema of eyelids; necrosis of respiratory tract and exposed skin; nausea, vomiting^H.	Eyes, respiratory system, skin^H		Carcinogen. 1-14 day = TWA (8 hr).
Sulfuric acid 7664-93-9	(2)	(10)	(30)	(1)	Severe lung damage; loss of vision; corrosion of mucous membranes; nausea, vomiting.	Respiratory system	(1)	Carcinogen; lung.

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms[‡N]	Target Organ[N]	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Sulfuryl fluoride 2699-79-8	**ND**	**ND**	**200** (835)	**0.5** (2.1)	Conjunctivitis, rhinitis, pharyngitis, paresthesia; liquid; frostbite: in animals: narcosis, tremor, convulsions; pulmonary edema; kidney injury.	Eyes, skin, respiratory system, CNS, kidneys		
Tellurium hexafluoride 7783-80-4	**0.06** (0.6)	**1** (10)	**1** (10)	**0.02** (0.2)	Headache; difficulty breathing; garlic breathing; in animals: pulmonary edema	Respiratory system		
Tetrachloroethane (1,1,2,2-) 79-34-5	**3** (20.6)	**5** (3.4)	**100** (686)	**0.1** (0.7)	Nausea, vomiting, abdominal pain; tremor fingers; jaundice, hepatitis; monocytosis (increased blood monocytes); kidney damage.	Skin, liver, kidneys, CNS, gastrointestinal tract	**3**	Pungent chloroform-like odor; potential occupational carcinogen.
Tetraethyl lead 78-00-2	(0.13)	(0.75)	(4.0)	(0.01^S)	Insomnia, lassitude, anxiety; tremor, hyper-reflexia, spasticity; bradycardia, hypotension, hypothermia, pallor, nausea, loss of appetite, weight loss; confusion, hallucinations, psychosis, mania, convulsions, coma; eye irritation.	CNS, Cardiovascular system, kidneys, eyes		
Tetramethyl lead 75-74-1	**ND**	**ND**	(40)	(0.02)	Insomnia, restlessness, anxiety; hypotension; nausea, loss of appetite; delirium, mania, convulsions; coma.	CNS, cardiovascular system, kidneys		
Titanium tetrachloride 7550-45-0	(5)	(20)	(100)	**ND**	Cornea damage, congestion of the mucous membrane of the pharynx, vocal cords, and trachea; stenosis of larynx, trachea and upper bronchi; skin irritation[H].	Skin, eyes, mucous membranes, upper respiratory system[H]		
Toluene 108-88-3	**50** (188)	**300** (1131)	**1000** (3769)	**3** (11)	Irritation eyes, nose; fatigue, weakness, confusion, euphoria, dizziness, headache; dilated pupils, excessive tearing; nervousness, muscle fatigue, insomnia; paresthesia; dermatitis; liver, kidney damage.	Eyes, skin, respiratory system, CNS, liver and kidneys	**2.9**	Pungent, benzene-like odor.

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms[‡N]	Target Organ[N]	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Toluene 2,4-diisocyanate 584-84-9	**0.02** (0.14)	**1** (7.1)	**2.5** (18)	**0.005** (0.036)	Irritation eyes, skin, nose, throat; choke, paroxysmal cough; chest pain; vomiting, abdominal pain; bronchospasm, pulmonary edema; difficulty breathing, asthma; conjunctivitis, excessive tearing; dermatitis, skin sensitization.	Eyes, skin, respiratory system		Known sensitizer. Subsequent exposures may lower effect concentration. Potential occupational carcinogen; strong, pungent odor.
Trichloroethylene 79-01-6	**100** (537)	**500** (2687)	**5000** (26,870)	**5** (27)	Headache, fatigue, and irritability.	CNS	**28**	
Trichloropropane (1,2,3-) 96-18-4	**30** (181)	**50** (302)	**100** (603)	**1[S]** (6)	Irritation eyes, nose, throat; CNS depressant/depression; in animals: liver, kidney injury.	Eyes, skin, respiratory system, CNS, liver, kidneys		Dermal exposure may contribute to total dose; potential occupational carcinogen.
Tungsten hexafluoride 7783-82-6	**ND**	**ND**	**ND**	(0.1)	Nausea, vomiting, abdominal pain, convulsions, and kidney damage; irritation of the eyes, nose, throat, and skin.	Kidney, CNS, eyes, skin, upper respiratory system		These acute symptoms were based on exposure to high levels of fluorides; no known health effects from exposure to tungsten hexafluoride[NJ]; 1-14 day value based on soluble tungsten.
VX 50782-69-9	(0.0015)	**NA**	(0.02)	(0.00003)	AChE inhibitor; CNS effects: headache, runny nose and nasal congestion, nausea, vomiting, giddiness, anxiety, difficulty in sleeping/thinking, muscle twitching, weakness, abdominal cramps.	CNS		Values based on antichloinesterase activity. 1-hr = Ct; 1-14 day = General Population Limit.

Compound	1-Hour MAGs-S ppm (mg/m^3)			1-14 Day MAGs-S ppm (mg/m^3)	Potential Toxic Symptoms[‡N]	Target Organ[N]	Odor Threshold ppm (mg/m^3)	Notes
	Minimal effects level	Significant effects level	Severe effects level					
Xylene (mixed) 1330-20-7	**150** (650)	**200** (868)	**900** (3906)	**10** (43)	Lightheadedness, nausea, headache, and ataxia at low doses and confusion; respiratory depression and coma at high doses; above 200 ppm, xylene causes conjunctivitis, nasal irritation, and sore throats; it is a potent respiratory irritant at high concentrations; dermatitis with prolonged cutaneous exposure.[H]	CNS, eyes, skin, respiratory passages, mucous membranes[H]	**0.081 - 40**	Sweet, aromatic odor.

Notes:
MAGs-S – Military Air Guidelines – Short Term.
I – Acute Exposure Symptoms which may occur at exposures above MAGs-S.
♦ - Indicates value less than 1-14 day value, based on objectionable odor, differences in professional judgment between organizations in value derivation, or derived based on applications to sensitive subpopulations (e.g., asthmatics).
N – National Institute of Safety and Occupational Health (NIOSH) Pocket Guide (unless otherwise noted).
c – Ceiling value (ACGIH, 1998).
s – Skin notation; dermal exposures have the potential for significant contribution to overall dose.
CNS – Central Nervous System.
R – Chemical Hazard Response Information System.
H – Hazardous Substances Data Base.
NJ – New Jersey Substance Fact Sheet.
T – Compton, James A. F. 1987. *Military Chemical and Biological Agents*, The Telford Press, Caldwell, NJ.
M – National Research Council, Committee on Toxicology. 1997. *Toxicity of Military Smokes and Obscurants,* National Academy Press, Washington, DC.
NA – Not Available; data insufficient to derive a value.
ND – Not Determined; data not yet reviewed to derive a value.

† - Compounds classified per ACE Policy for Defensive Measures against Toxic Industrial Chemical Hazards during Military Operations (NATO/PFP, 1996).
RTECS – Registry of Toxic Effects of Chemical Substances.

The primary sources of odor thresholds in air were the *Odor Thresholds for Chemicals with Established Occupational Health Standards,* published by the American Industrial Hygiene Association, Akron, OH, 1989, and the N. J. Hazardous Substances Fact Sheets.

APPENDIX D

MILITARY WATER GUIDELINES - SHORT TERM (MWGs-S) TABLE

GROUPED LISTING OF CHEMICALS

The following groups of compounds are provided for quick reference. Groups include various chemical categories as well as some general "prioritization" of compounds which are of significant toxicity and are deemed somewhat widespread in use/production/environmental contamination. These groups are for general consideration only. Decisions on sampling should be based on a site-specific evaluation.

Chemical Warfare Agents

High Priority

Medium Priority

Low Priority

Unknown Priority

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Acifluorfen 5094-66-6	**2.8**	**0.9**	**2.8**	**0.9**	Liver changes.	Liver		Probable human carcinogen.
Acrylamide 79-06-1	**2**	**.7**	**0.4**	**0.14**	Sleepiness, hallucinations, disorientation, incoordination in the legs, weakness, tremors, and possibly seizures.	CNS, peripheral nervous system		Effects of high exposure may be delayed in onset for several hours. Probable human carcinogen.
Acrylonitrile** 107-13-1	**0.5**	**0.14**	**0.5**	**0.14**	Headache, irritability, light-headedness, impaired judgment, nausea, vomiting, diarrhea, abdominal pain, weakness; higher concentrations may cause liver damage, anemia, irregular breathing, and seizures; exposure *in utero* may cause birth defects.	Cardiovascular system, liver, kidneys, CNS, reproductive system		Ingestion of 1.5 to 2 gm (300-400 mg/L) can cause severe, lasting effects. Probable human carcinogen.
Adipate (diethylhexyl) 103-23-1	**28**	**9.3**	**28**	**9.3**	Short-term effects from exposure in drinking water are unknown.	Liver, testes		Possible human carcinogen.
Alachlor 15972-60-8	**0.14**	**0.05**	**0.14**	**0.05**		Liver, kidney, spleen		Probable human carcinogen.
Aldrin 309-00-2	**0.0004**	**0.0001**	**0.0004**	**0.0001**	Nausea, vomiting, diarrhea, hyperexcitablity, tremors, limb jerks, convulsions, and ventricular fibrillation; reversible kidney and liver injury.	CNS, liver, kidneys	Odor: 0.017 mg/L	Ingestion of 25.6 mg/kg (360 mg/L) can produce convulsions; a single oral dose of 5 g (1 g/L) was lethal. Probable human carcinogen.
Ametryn 834-12-8	**12**	**4**	**12**	**4**	Incoordination, shortness of breath, muscle weakness, salivation, and loss of reflexes.	Liver, CNS		
Ammonia 7664-41-7	**3.4**	**3.4**	**3.4**	**3.4**	Very high concentrations are corrosive and can cause ulcerative esophagitis. Such levels are not likely to be found in drinking water.		Odor and taste: 3.4 mg/L	Exposure guideline for ammonia based on odor and taste threshold; can react with the water supply disinfectant hypochlorite to produce objectionable tastes and odors.
Ammonium sulfamate 7773-06-0	**90**	**30**	**90**	**30**	Gastrointestinal disturbances.	Gastrointestinal tract		A military adjustment factor of 3 has been applied.
Antimony 744-36-0	**0.006**	**0.002**	**0.006**	**0.002**	Irritation of the nose, mouth, nose and intestines; nausea, vomiting, diarrhea, bloody stools, stomach cramps, difficulty breathing, weight and hair loss, dry scaly skin; heart, liver, and kidney congestion.	Gastrointestinal tract, cardiovascular system, liver, kidney		Doses between 1 and 1.5 mg/kg (14-21 mg/L) may cause severe vomiting, diarrhea and death.

* Notes for table on page D-30.

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Arsenic 7440-38-2 *TB MED 577	**0.3**	**0.1**	**-**	**-**	Facial swelling, vomiting, loss of appetite, abdominal pain; diarrhea, shock, muscle cramps, headache, chill, cardiac abnormalities, anemia, decreased white blood cell count, and enlargement of liver; delayed effects include sensory and motor peripheral polyneuropathies.	Liver, kidney, circulatory system, CNS, gastrointestinal tract, immune system		The risk of developing symptoms of acute toxicity increases as the concentration in drinking water increases above 0.3 mg/L. The risk of severe toxic effects and fatalities increases as concentrations rise above 14 mg/L. Known human carcinogen.
Atrazine**** 1912-24-9	**0.7**	**0.23**	**0.7**	**0.23**	Congestion of heart, lungs and kidneys; hypotension, urine retention, muscle spasms, loss of appetite, salivation, depression of activity, incoordination, fever, and shortness of breath.	Eyes, CNS, cardiovascular system		Possible human carcinogen.
Baygon 114-26-1	**0.06**	**0.02**	**0.06**	**0.02**	Headache, constricted pupils, blurred vision, nausea, vomiting, abdominal cramps, diarrhea, salivation, sweating, tearing, runny nose, lassitude, weakness, chest tightness, loss of coordination, slurred speech, muscle twitching, breathing difficulty, and incontinence; higher concentrations can cause convulsions and coma; fetal death and birth defects have been observed in experimental animals.	CNS, gastrointestinal tract, blood cholinesterase inhibitor		A single oral dose of 0.36 mg/kg (5 mg/L) caused transient stomach discomfort, blurred vision and sweating. Ingestion of a single oral dose of 1.5 mg/kg (21 mg/L) caused blurred vision, nausea, sweating, rapid heartbeat, and vomiting. The effects occurred within 15-20 minutes after exposure and disappeared within 2 hours. Possible human carcinogen.
Bentazon 25057-89-0	**0.4**	**0.1**	**0.4**	**0.1**	Vomiting, diarrhea, difficulty breathing, weakness, apathy, incoordination, and tremors.	CNS		
Benzene 71-43-2	**0.3**	**0.1**	**0.3**	**0.1**	Vomiting, loss of coordination, light-headedness, headache, anemia, shallow/rapid pulse, loss of concentration, delirium, chemical pneumonitis, dizziness, pallor, flushing, weakness, and breathlessness; high concentrations may cause convulsions, coma, or irregular heart beat.	Eyes, skin, respiratory system, blood, CNS, bone marrow, immune system	Odor: 2.0 mg/L Taste: 0.5 - 4.5 mg/L	The mean lethal dose has been estimated to be 13 gm (2.6 g/L). Known human carcinogen.

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Beryllium 7440-41-7	**36**	**12**	**36**	**12**	Low acute toxicity by ingestion.	Bone		Probable human carcinogen.
Boron 7440-42-8	**5**	**1.7**	**1.2**	**0.4**	Vomiting, abdominal pain, diarrhea; headache, tremors, restlessness, weakness, convulsions; may affect the liver, and may cause skin rash and desquamation.	CNS, skin, kidneys		Ingestion of 1.8 to 3.6 mg/kg (25-50 mg/L) boron caused no effects in volunteers. Ingestion of 22.5 mg/kg (315 mg/L) produced erythema, desquamation, and CNS effects. The mean lethal oral dose has been estimated to be over 400 mg/kg (5.6 g/L) in humans and the lowest oral lethal dose has been estimated as 112 mg/kg (1.6 g/L).
Bromacil 314-40-9	**7**	**2**	**7**	**2**	Vomiting, salivation, muscular weakness, excitability, diarrhea, and mydriasis.	Thyroid		Possible human carcinogen.
Bromochloromethane 74-97-5	**1.4**	**0.5**	**1.4**	**0.5**	Loss of appetite, nausea, vomiting, abdominal pain, severe headache, confusion, dizziness, memory impairment, weakness, tremors and convulsions; elevated carboxyhemoglobin.	Liver, kidney, CNS	Odor: 34 mg/L	
Bromodichloromethane 75-27-4	**8.4**	**2.8**	**8.4**	**2.8**	CNS functional disturbances, including sedation, anesthesia, incoordination, and depression of rapid eye movement sleep; increased blood levels of methemoglobin.	CNS, liver, kidney		Probable human carcinogen.
Bromoform 75-25-2	**7**	**2**	**3**	**1**	Headache, dizziness, disorientation, listlessness, amnesia and slurred speech, shock, unconsciousness, and convulsions.	CNS, liver, kidneys		Probable human carcinogen.
Bromomethane 74-83-9	**0.2**	**0.07**	**0.2**	**0.07**	Tremor, convulsions, shortness of breath.	CNS		
Butylate 2008-41-5	**3**	**1**	**3**	**1**				

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
BZ *TB MED 577	**0.007**	**0.0023**	**-**	**-**	Elevated heart rate and blood pressure, facial flushing, dryness of the throat and mouth, loss of appetite, weakness, fatigue, and blurred vision; higher concentrations may cause tremors of the lips and arms, facial muscle twitches, speech difficulties, severe mental depression, and confusion.	CNS		The risk of severe and enduring performance-degrading effects increases as the concentration of BZ in drinking water increases above 0.007 mg/L. Concentrations of 0.014 mg/L can cause blurred vision, dry mouth and mild incapacitation; 0.028 mg/L may cause delirium.
Cadmium 7440-43-9	**0.06**	**0.02**	**0.06**	**0.02**	Nausea, vomiting, diarrhea, muscle cramps, salivation, sensory disturbances, liver injury, convulsions, shock, and renal failure.	Kidney, liver		Ingestion of 3 mg (0.6 mg/L) may cause vomiting; 30 mg (6 mg/L) of soluble cadmium salts can produce severe toxic symptoms; 350 mg (70 mg/L) may be fatal.
Carbaryl 63-25-2	**1.4**	**0.5**	**1.4**	**0.5**	Nausea, vomiting, abdominal cramps, diarrhea, salivation, sweating, lassitude, weakness, runny nose, chest tightness, blurred or dim vision, miosis, tearing, loss of coordination, slurred speech, muscle twitching, tremor, breathing difficulty, cyanosis, hypertension, jerky movements, incontinence, convulsions, coma, and respiratory paralysis.	CNS, reproductive system, cardiovascular system, cholinesterase inhibitor		Single doses of 0.5 to 2.0 mg/kg (7 - 28 mg/L) and repeated daily doses of 0.13 mg/kg (1.82 mg/L) taken for 6 weeks caused no adverse effects in volunteers. But ingestion of single doses of 2.8 mg/kg (39 mg/L) or 5.45 mg/kg (76 mg/L) produced moderately severe poisoning with vomiting, pain and lassitude in other individuals; 5.7 g/kg (80 g/L) has been fatal.
Carbofuran 1553-66-2	**0.07**	**0.02**	**0.07**	**0.02**	Headache, weakness, nausea, light-headedness, miosis, blurred vision, abdominal cramps, excessive perspiration and salivation, diarrhea, vomiting, muscle twitching, incoordination, and convulsions.	Peripheral nervous system, blood cholinesterase inhibitor		A single dose of 0.05 mg/kg (0.7 mg/L) caused no symptoms in volunteers; 0.1 mg/kg (1.4 mg/L) caused headache and light headedness; 0.25 mg/kg (3.5 mg/L) produced salivation, abdominal pain, drowsiness, dizziness, anxiety and vomiting.
Carbon disulfide** 75-15-0	**0.14**	**0.05**	**0.14**	**0.05**	Dizziness, headache, nausea, vomiting, diarrhea, fatigue, palpitations and weakness; high concentrations may cause psychosis, tremor, delirium, coma, muscle spasm, convulsions, difficulty breathing, and liver damage.	CNS, peripheral, liver, reproductive system		

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Carbon tetrachloride 56-23-5	**5.6**	**2**	**0.2**	**0.07**	Nausea, vomiting, abdominal pain, diarrhea, headache, drowsiness, dizziness, weakness, blurred vision, incoordination, confusion, disorientation, anesthesia, and tremors; liver and kidney damage.	CNS, liver, kidneys	Odor: 0.52 mg/L	A single oral dose of 3 ml (1 g/L) caused dizziness and a dose of 6 ml (2.0 g/L) caused sleepiness, giddiness, and headache in volunteers. Doses in excess of 500 mg/kg (7 g/L) have been reported to cause nausea, vomiting, abdominal pain, CNS and liver damage. But some individuals have suffered severe adverse effects from ingestion of 34 mg/kg (480 mg/L). Consumption of alcohol strongly exacerbates the effects of carbon tetrachloride. Probable human carcinogen.
Carboxin 5234-68-4	**1.4**	**0.5**	**1.4**	**0.5**	Depression, difficulty breathing, seizures.	CNS		
Chloral hydrate 302-17-0	**1**	**0.3**	**0.3**	**0.1**	Light-headedness, malaise, deep stupor, incoordination, and nausea; occasional vomiting, flatulence, stomach ulcers; respiratory depression and hypotension; large doses may cause cardiac arrhythmia.	CNS, gastrointestinal tract, cardiovascular system, liver, kidney		Possible human carcinogen.
Chloramben 133-90-4	**3.5**	**1.2**	**3.5**	**1.2**	Skin or eye contact may cause irritation.			
Chlordane 57-74-9	**0.09**	**0.03**	**0.09**	**0.03**	Nausea, vomiting, diarrhea, headache, excitability, confusion, weakness, incoordination; high concentrations may cause delirium, muscle spasms, convulsions or seizures, coma, pulmonary edema, and difficulty breathing.	CNS, liver, kidney		Ingestion of 28 to 56 mg/kg (390-780 mg/L) may cause severe effects such as convulsions. The fatal human dose lies between 6 and 60 gm (1 and 10 g/L). The onset of symptoms occurs 45 minutes to several hours after ingestion. Probable human carcinogen.
Chloride *TB MED 577	**600**	**600**	**600**	**600**	Reduced water consumption due to high chloride concentrations can lead to dehydration, with symptoms including weariness, apathy, impaired coordination, delirium, heat stroke.			Exposure guidelines are based on palatability; at 600 mg/L, 2% of the military population might refuse to drink water and may suffer dehydration; at 1,000 mg/L, 10% would be at risk of dehydration.

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Chlorobenzene 108-90-7	**3**	**1**	**3**	**1**	Drowsiness, dizziness, light-headedness, muscle spasms, and coma; impaired liver and kidney function.	CNS, liver, kidney	Odor: 0.05 mg/L Taste: 0.010 - 0.02 mg/L	
Chlorodibromo-methane 124-48-1	**8.4**	**2.8**	**8.4**	**2.8**	Incoordination, depression of rapid eye movement, sleep, sedation, anesthesia, increased blood levels of methemoglobin; injury of the liver, kidneys and adrenals.	CNS, liver, kidneys		Possible human carcinogen.
Chloroisopropyl ether (bis-2-) 108-60-1	**5.6**	**2**	**5.6**	**2**			Odor: 0.2 - 0.32 mg/L	
Chloroform 67-66-3	**6**	**2**	**6**	**2**	Dizziness, mental dullness, headache, nausea, confusion, fatigue, narcosis, liver and kidney damage.	Kidneys, CNS		Carcinogen.
Chloromethane [Methyl chloride] 74-87-3	**12**	**4**	**0.5**	**0.17**	Headache, drowsiness, giddiness, dizziness, confusion, incoordination, vomiting, abdominal pain, diarrhea, breathing difficulties; high concentrations may cause unconsciousness, convulsions, coma, visual disturbances, and may damage the kidneys, liver, or blood.	CNS, liver, kidneys, reproductive system		Symptoms of chloromethane exposure may be delayed in onset. Possible human carcinogen.
Chlorophenol (2-) 95-57-8	**0.8**	**0.3**	**0.8**	**0.3**	Restlessness, rapid breathing, and muscle weakness, followed by tremors, seizures, and coma.	CNS, liver, kidneys	Odor: 0.0001 mg/L	Can react with the water supply disinfectant hypochlorite to produce objectionable tastes and odors.
Chlorothalonil 1897-45-6	**0.35**	**0.12**	**0.35**	**0.12**	Vomiting, rapid breathing, gastrointestinal irritation, weakness, and sedation.	CNS, gastrointestinal tract, urogenital tract		Probable human carcinogen.
Chlorotoluene o- 95-49-8	**2.8**	**0.9**	**2.8**	**0.9**			Odor: 0.0069 mg/L	
Chlorotoluene p- 106-43-4	**2.8**	**0.9**	**2.8**	**0.9**				

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Chlorpyrifos 2921-88-2	**0.04**	**0.014**	**0.04**	**0.014**	Headache, fatigue, dizziness, mental confusion, disorientation, tearing, salivation; cyanosis, constricted pupils, blurred vision, weakness, nausea, vomiting, abdominal cramps, diarrhea, muscle spasms and twitching, convulsions, coma, loss of reflexes, and incontinence. May possibly cause delayed peripheral neuropathy and birth defects.	CNS, peripheral nervous system, plasma cholinesterase inhibitor		A single oral dose of 0.5 mg (0.1 mg/L) caused a 15% depression of plasma cholinesterase and no signs of toxicity in volunteers. Ingestion of 0.1 mg/kg/day (1.4 mg/L) for 9 days depressed plasma cholinesterase and had no other effects in volunteers; 0.03 mg/kg/day (0.42 mg/L) for 20 days caused no significant effects. Ingestion of 300 mg (60 mg/L) caused loss of consciousness and acute signs of cholinergic toxicity followed by long-term neurologic effects.
Chromium (total) 7440-47-3	**2**	**0.7**	**2**	**0.7**	Hexavalent chromium compounds are more toxic than trivalent chromium compounds; ingestion of hexavalent chromium compounds may cause intense gastrointestinal irritation, violent epigastric pain, nausea, vomiting, diarrhea, bleeding, circulatory collapse, unconsciousness, and death; liver and kidney damage are possible with large exposures.	Kidney, liver		Doses of 0.5 to 1.5 g (100 - 300 mg/L) have caused fatalities.
Cyanazine 21725-46-2	**0.14**	**0.05**	**0.14**	**0.05**	Weakness, nausea and difficulty breathing; may affect kidney function. Birth defects have been observed in the offspring of experimental animals.	Blood, kidney		Possible human carcinogen.
Cyanide *TB MED 577	**6**	**2**	**6**	**2**	Headache, breathlessness, weakness, palpitation, nausea, vomiting, giddiness, tremor, rapid heart beat, dizziness, confusion, anxiety, agitation, confusion, cardiac arrhythmias, seizures, stupor, and coma.	CNS, respiratory system, cardiovascular system, liver, kidneys		Concentrations between 12 and 24 mg/L may cause changes in blood chemistry without clinical effects. Severe but reversible symptoms may occur at concentrations of 24 to 48 mg/L; concentrations higher than 48 mg/L cause life-threatening toxicity.

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
2,4-D (2,4-Dichlorophenoxyacetic acid) 94-75-7	**1.5**	**0.5**	**0.4**	**0.14**	Nervous system damage, vomiting, diarrhea, lethargy, incoordination, weakness, paralysis, stupor, miosis, stiffness in the extremities, muscle twitching and spasms, lowered blood pressure, convulsions; transient liver and kidney damage; may cause birth defects and reduced fertility.	CNS, liver, kidneys		Ingestion of a single dose of 5 mg/kg (70 mg/L) and repeated doses of 7 mg/kg/day (98 mg/L) for 21 days caused no effects. The single oral lethal dose has been estimated to be 355 mg/kg (5 g/L). Survival following a dose of about 110 mg/kg (1.5 g/L) has been reported.
Dalapon 75-99-0	**4.2**	**1.4**	**4.2**	**1.4**	CNS depression, lassitude, loss of appetite, diarrhea, vomiting, slowing of pulse.	Gastrointestinal tract, CNS		
DCPA [Dacthal] 1861-32-1	**105**	**35**	**105**	**35**				Single oral doses of 50 mg (10 mg/L) caused no observable effects in volunteers.
Diazinon 333-41-5	**0.03**	**0.009**	**0.03**	**0.009**	Nausea, vomiting, diarrhea, headache, dizziness, weakness, excessive tearing and salivation, ocular pain, blurring/ dimness of vision, miosis, loss of muscle coordination, slurred speech, muscle twitching, disorientation, drowsiness, difficulty breathing, hypertension, hypotension, cardiac arrhythmias, random jerky movements, incontinence, convulsions, and coma.	Eyes, respiratory system, CNS, cardiovascular system, blood, cholinesterase inhibitor		
Dibromoacetonitrile 3252-43-5	**2.8**	**0.94**	**2.8**	**0.94**				Possible human carcinogen.
Dibromochloropropane 96-12-8	**0.28**	**0.09**	**0.07**	**0.024**	Gastrointestinal distress; may damage the kidney, liver, and testes.	Liver, kidney, spleen, male reproductive system, gastrointestinal tract, CNS	Odor: 0.01 - 3.1 mg/L	
Dicamba 1918-00-9	**0.4**	**0.14**	**0.4**	**0.14**	Vomiting, loss of appetite, headache, dizziness, weakness, difficulty breathing, muscle weakness and spasms.	CNS		
Dichloroacetic acid 79-43-6	**1.5**	**0.5**	**1.5**	**0.5**	Decreased plasma lactate and glucose levels; high concentrations may cause birth defects.	Reproductive system		Probable human carcinogen.

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Dichloroacetonitrile 3018-12-0	**1.4**	**0.5**	**1.4**	**0.5**	Nausea, vomiting, weakness, stupor, convulsions, and delirium; liver and kidney damage.	Cardiovascular system, CNS, liver, kidneys		Possible human carcinogen.
Dichlorobenzene m- 541-73-1	**12.6**	**4.2**	**12.6**	**4.2**	Headache, drowsiness, unsteadiness; irritation of gastric mucosa, nausea, vomiting, diarrhea, abdominal cramps and cyanosis.	CNS, liver, kidneys		
Dichlorobenzene o- 95-50-1	**12.6**	**4.2**	**12.6**	**4.2**	Headache, nausea, vomiting, and diarrhea; higher doses can produce dizziness, sleepiness, loss of coordination and judgment; methemoglobinemia, hemolytic anemia, and kidney damage.	Liver, kidneys, CNS		
Dichlorobenzene p- 106-46-7	**15**	**5**	**15**	**5**	High concentrations may cause nausea, vomiting, headaches, liver and kidney injury, anemia, and jaundice.	Liver, kidneys, CNS		Possible human carcinogen.
Dichlorodifluoro-methane 75-71-8	**60**	**20**	**60**	**20**	Relatively non-toxic by ingestion.	Nervous system, cardiovascular system		The systems listed under target organs are those known to be affected by inhalation.
Dichloroethane (1,2-) 107-06-2	**1**	**0.3**	**1**	**0.3**	Headache, dizziness, drowsiness, cyanosis, nausea, vomiting and diarrhea; high concentrations can cause gastrointestinal disorders, transient kidney damage, liver injury, and reduced blood pressure.	Kidneys, liver, CNS, cardiovascular system	Odor: 29 mg/L; Taste: 29 mg/L	Ingestion of 20 – 50 ml (5 to 12.6 g/L) can cause severe neurological effects and may be fatal. Probable human carcinogen.
Dichloroethylene (1,1-) 75-35-4	**2.8**	**1**	**1.4**	**0.5**	Dizziness, headache, nausea, liver and kidney dysfunction.	Liver, kidney, CNS		Possible human carcinogen.
Dichloroethylene (cis-1,2-) 156-59-2	**5.6**	**2**	**4.5**	**1.5**	CNS depression, decreased red blood cell count.	CNS, blood		The *trans* form is approximately twice as potent as the *cis* form in its depression of the CNS.
Dichloroethylene (trans-1,2-) 156-60-5	**28**	**9.4**	**2**	**0.7**	CNS depression, difficulty breathing, incoordination, decreased red blood cell count.	CNS, blood		The *trans* form is approximately twice as potent as the *cis* form in its depression of the CNS.
Dichloromethane [Methylene chloride] 75-09-2	**14**	**5**	**2.8**	**1**	Dizziness, sleepiness, fatigue, weakness, light-headedness, numbness, tingling in limbs.	Cardiovascular system, CNS, blood		Probable human carcinogen.

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Dichlorophenol (2,4-) 120-83-2	**0.04**	**0.01**	**0.04**	**0.01**	Abdominal pain, vomiting, bloody diarrhea; pallor, sweating, weakness, headache, dizziness; possibly fleeting excitement and confusion, tremors, convulsions, unconsciousness; dark-colored urine, kidney damage, methemoglobinemia and hemolytic anemia.	CNS, liver, kidneys		
Dichloropropane (1,2-) 78-87-5	**0.13**	**0.04**	**0.13**	**0.04**	Headache, dizziness; damage to the liver, kidneys, adrenal glands, bladder, and the gastrointestinal tract; hemolytic anemia.	Liver, kidney, gastrointestinal tract		Probable human carcinogen.
Dichloropropene (1,3-) 542-75-6	**0.042**	**0.014**	**0.042**	**0.014**	Weakness, headache, dizziness, lethargy, incoordination, and depressed respiration; may damage the lungs, liver, and kidneys and cause lesions in the gastrointestinal tract.	Respiratory tract, CNS, liver, kidneys, gastrointestinal tract		Probable human carcinogen.
Dieldrin 60-57-1	**0.0007**	**0.00023**	**0.0007**	**0.00023**	Early signs of toxicity are headache, dizziness, nausea, vomiting, malaise, sweating, tremors, limb jerks, EEG changes, convulsions, and coma; secondary effects include hypertension, cardiac arrhythmias, and fever; sleep, memory, behavioral disturbances, headache, and convulsions may persist for months following exposure.	CNS	Odor: 0.04 mg/L	No effects were seen in volunteers given doses of 0.21 mg (0.04 mg/L). Serious effects may occur at a dose of 10 mg/kg (140 mg/L); 29 mg/kg (420 mg/L) caused profuse vomiting or prolonged convulsions; the acute mean lethal dose for humans has been estimated to lie between 20 and 70 mg/kg (280 to 980 g/L). Probable human carcinogen.
Di(2-ethylhexyl) phthalate 117-81-7	**14**	**4.7**	**14**	**4.7**	Mild gastrointestinal disturbances, nausea, dizziness; may cause birth defects.	CNS, liver, reproductive system		A single dose of 10 g (2 g/L) caused mild gastric disturbances and catharsis. Probable human carcinogen.
Diisopropylmethyl-phosphonate [DIMP] 1445-75-6	**30**	**10**	**30**	**10**	High concentrations may cause lethargy and other signs of CNS depression.	CNS		A military adjustment factor of 3 has been applied.
Dimethrin 70-38-2	**16.8**	**5.5**	**16.8**	**5.5**	Drowsiness, dizziness, headache, nausea, vomiting, diarrhea, gastritis, loss of appetite, fatigue, and weakness.	CNS, liver, gastrointestinal tract		

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Dimethyl methyl phosphonate 756-79-6	**2.5**	**0.8**	**2.5**	**0.8**	High concentrations may cause lethargy and other signs of CNS depression.	CNS		Possible human carcinogen.
Dinitrobenzene (1,3-) 99-65-0	**0.06**	**0.02**	**0.06**	**0.02**	Methemoglobinemia associated with headache, irritability, dizziness, weakness, nausea, lethargy, shortness of breath, liver damage.	Blood, liver, CNS, cardiovascular system		The lethal dose has been estimated to lie between 5 and 50 mg/kg (70 and 700 mg/L).
Dinitrotoluene (2,4-) 121-14-2	**0.6**	**0.2**	**0.6**	**0.2**	Methemoglobinemia with symptoms of nausea, vomiting, headache, weakness, dizziness, and drowsiness; high concentrations may cause difficulty breathing, hypotension, arrhythmia, damage to liver and testes, and anemia; exposure may affect developing fetus.	Red blood cells, CNS, testes		Consumption of alcohol may exacerbate the toxicity of dinitrotoluene. Probable human carcinogen.
Dinitrotoluene (2,6-) 606-20-2	**0.6**	**0.2**	**0.6**	**0.2**	Methemoglobinemia with symptoms of nausea, vomiting, headache, weakness, dizziness, and drowsiness; high concentrations may cause difficulty breathing, hypotension, arrhythmia, damage to liver and testes; exposure may affect fetus.	Red blood cells, CNS, testes		Consumption of alcohol may exacerbate the toxicity of dinitrotoluene. Probable human carcinogen.
Dinoseb 88-85-7	**0.42**	**0.14**	**0.42**	**0.14**	Nausea, vomiting, abdominal pain, marked thirst, fatigue, sweating, facial flushing, rapid heart beat, hyperthermia, respiratory distress, cyanosis, restlessness, anxiety, muscle cramps, excitement, convulsions, and coma.	CNS, reproductive system		
Dioxane (1,4-) 123-91-1	**5.6**	**2**	**0.56**	**0.2**	Nausea, headache, liver and kidney damage.	Liver, kidneys, CNS		Probable human carcinogen.
Diphenamid 957-51-7	**0.4**	**0.13**	**0.4**	**0.13**	Vomiting, salivation, incoordination, prostration, spasms and convulsions.	CNS, liver		
Diphenylamine 122-39-4	**1.6**	**0.6**	**1.6**	**0.6**	Fast pulse, hypertension, methemoglobinemia, bladder injury; may cause birth defects.	Cardiovascular system, bladder, reproductive system		

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Disulfoton 298-04-4	**0.014**	**0.005**	**0.014**	**0.005**	Headache, loss of appetite, nausea, vomiting, abdominal cramps, diarrhea, weakness, dizziness, confusions, slurred speech, salivation, tearing, profuse sweating, shortness of breath, tightness of the chest, changes in heart rate, cyanosis, miosis, blurred vision, runny nose, slow pulse, muscle twitching, tremors, muscle cramps, incoordination, convulsions, coma, and shock.	Eyes, respiratory tract, CNS, cardiovascular system, blood cholinesterase		Oral doses of 0.75 mg/day (0.15 mg/L) for 30 days produced no significant effects in volunteers. The human LD_{50} has been estimated to be 5 mg/kg (70 mg/L).
Dithiane (1,4-) 505-29-3	**0.5**	**0.2**	**0.5**	**0.2**	Incoordination, lacrimation, lethargy, diarrhea.	Gastrointestinal tract, CNS		
Diuron 330-54-1	**1.4**	**0.5**	**1.4**	**0.5**	Diuretic effects; high concentration may cause CNS depression; has caused birth defects and fetal deaths in experimental animals.	Blood, CNS		
EA 2192* **	**0.015**	**0.005**	**-**	**-**	Nausea, vomiting, diarrhea, cramps, headache, giddiness, dizziness, excessive salivation, tearing, miosis, blurred or dim vision, difficulty breathing, cardiac arrhythmias, loss of muscle coordination, muscle twitching, random jerking movements, convulsions, coma.	CNS, cholinesterase inhibitor		
Endothall 145-73-3	**1.1**	**0.4**	**1.1**	**0.4**	Hypotension, depressed breathing and heart rate, vomiting, diarrhea, dilated pupils, loss of coordination, transient excitation followed by general depression, sluggishness, spasmodic twitching, seizures.	CNS		Ingestion of 100 mg/kg (1.4 g/L) can be fatal.
Endrin 72-20-8	**0.035**	**0.01**	**0.02**	**0.007**	Headache, dizziness, nausea, vomiting, hypersalivation, insomnia, lethargy, weakness, agitation and confusion; high concentrations may cause convulsions, stupor, tremors, and coma; headache, dizziness, sleepiness, weakness, and loss of appetite may persist for 2 to 4 weeks.	CNS		Convulsions may be induced in humans by doses of 0.2 to 0.25 mg/kg (2.8 to 3.5 mg/L); a dose of 1 mg/kg (14 mg/L) can induce repeated seizures.

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Epichlorohydrin 106-89-8	**0.2**	**0.07**	**0.2**	**0.07**	Nausea, vomiting, abdominal pain, skin irritation; muscular relaxation or paralysis, tremor, convulsions; liver and kidney damage, cyanosis, impairment of male fertility and/or spermatogenesis.	Kidneys, liver, CNS, skin, male reproductive system	Odor: 0.5 – 3 mg/L	Probable human carcinogen.
Ethyl benzene 100-41-4	**45**	**15**	**4.5**	**1.5**	Headache, nausea, weakness, dizziness, sleepiness, fatigue, loss of coordination, and coma.	CNS	Odor: 0.062 mg/L; Taste: 0.025 mg/L	
Ethylene dibromide 106-93-4	**0.01**	**0.004**	**0.01**	**0.004**	Liver and kidney damage, vomiting, excitement and other CNS effects.	CNS, liver, kidneys, reproductive system		A single oral dose of 65 mg/kg (900 mg/L) may be lethal. Probable human carcinogen.
Ethylene glycol 107-21-1	**26**	**9**	**8**	**2.5**	Weakness, dizziness, inebriation, stupor; high concentrations may cause convulsions, coma, hypertension, rapid breathing, rapid heartbeat, and severe kidney damage.	CNS, cardiovascular system, kidney		Doses up to 190 mg/kg (2.6 g/L) produced no adverse effects in one individual. In other individuals, single doses of 1000 mg/kg (14 g/L) produced CNS effects including visual disturbances, light-headedness, headache and lethargy. Doses of 3000 mg/kg (42 g/L) caused ataxia, sleepiness slurred speech, disorientation and stupor and in some cases, were fatal. The mean lethal oral dose is about 110 g (22.3 g/L).
ETU (Ethylene thiourea) 96-45-7	**0.35**	**0.1**	**0.35**	**0.1**	Thyroid hyperplasia with changes in levels of thyroid hormones; may cause birth defects.	Thyroid, reproductive system, liver, immune system		Probable human carcinogen.
Fenamiphos 22224-92-6	**0.013**	**0.004**	**0.013**	**0.004**	Nausea, vomiting, abdominal cramps, diarrhea, salivation, headache, dizziness, weakness, runny nose, blurred vision, constricted pupils, incoordination, slurred speech, muscle twitches, random jerky movements, mental confusion, disorientation, drowsiness, difficulty breathing, cardiac irregularities, incontinence, convulsions, and coma.	CNS, cardiovascular system, blood cholinesterase inhibitor		
Fluometron 2164-17-2	**2.1**	**0.7**	**2.1**	**0.7**	Depression, deep rapid breathing, vomiting, coma.	CNS, blood, thyroid, liver, cholinesterase inhibitor		

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Fluorotrichloro-methane 75-69-4	**9.8**	**3.3**	**9.8**	**3.3**	Transient jaundice and liver enzyme elevation.	CNS, cardiovascular system, liver		Inhaled freons can affect the CNS and the heart, but effects are less severe following ingestion.
Fonofos 944-22-9	**0.03**	**0.009**	**0.03**	**0.009**	Loss of appetite, nausea, vomiting, abdominal cramps, diarrhea, headache, dizziness, weakness, confusion, blurred vision, constricted pupils, slurred speech, profuse sweating, salivation, and runny nose; cardiac irregularities, difficulty breathing, muscle twitching, paralysis, convulsions, coma, or respiratory arrest may occur.	CNS, cardiovascular system, blood cholinesterase inhibitor		
Formaldehyde 50-00-0	**14**	**5**	**8**	**2.6**	Nausea, vomiting, abdominal pain, diarrhea, lethargy, dizziness, hypotension, seizure.	Gastrointestinal tract, cardiovascular system	Odor: 20 mg/L; Taste: 50 ppm	The mean lethal dose is 1 to 2 oz. (4.9 – 9.8 g/L). Probable human carcinogen.
GA [Tabun] 77-81-6 *TB MED 577	**0.14**	**0.046**	**-**	**-**	Nausea, vomiting, abdominal cramps, diarrhea, headache, giddiness, dizziness, weakness, excessive tearing, blurred or dim vision, miosis, loss of muscle coordination, slurred speech, muscle twitching, confusion, disorientation, drowsiness, difficulty breathing, excessive salivation, cardiac arrhythmias, random jerking movements, incontinence, convulsions, coma.	CNS, cholinesterase inhibitor		Human oral LD_{50} values have been estimated at 0.357-0.714 mg/kg (5-10 mg/L).
GB [Sarin] 107-44-8 *TB MED 577	**0.028**	**0.0093**	**-**	**-**	See GA.	CNS, cholinesterase inhibitor		Minimal effects (e.g., excessive dreaming and talking during sleep) may occur after a single dose of 0.002 mg/kg (0.03 mg/L); mild effects (e.g., anorexia, fatigue, anxiety, tightness in the chest) can occur at 0.022 mg/kg (0.31 mg/L). The lethal oral dose has been estimated to be 0.071-0.285 mg/kg (1-4 mg/L).

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
GD [Soman] 96-64-0 *TB MED 577	**0.012**	**0.004**	**-**	**-**	See GA.	CNS, cholinesterase inhibitor		Oral LD_{50} values have been estimated at 0.005 to 0.020 mg/kg (0.07-0.28 mg/L).
Glyphosate 1071-83-6	**25**	**8**	**25**	**8**	Vomiting, diarrhea, abdominal pain; large doses may cause hypotension, tachycardia (rapid heart rate) and palpitations.	Kidneys		
Heptachlor 76-44-8	**0.014**	**0.005**	**0.014**	**0.005**	Nausea, vomiting, diarrhea, irritation of the gastrointestinal tract; higher exposures may cause liver damage, hyperexcitability, tremors, convulsions, and paralysis.	CNS, liver, gastrointestinal tract		A dose of 1 to 3 gm (200-600 mg/L) has been estimated to cause serious symptoms in humans, especially liver impairment. Probable human carcinogen.
Heptachlor epoxide 1024-57-3	**0.014**	**0.005**	**-**	**-**	Apprehension, agitation, muscle twitching and spasms, tremor, incoordination, vomiting, gastrointestinal upset, abdominal pain; higher doses may cause liver damage, and convulsions.	CNS, liver		Probable human carcinogen.
Hexachlorobenzene 118-74-1	**0.08**	**0.026**	**0.08**	**0.026**	Headache, nausea, cyanosis, muscle spasm, convulsions, liver injury, birth defects.	CNS, blood, liver, kidneys		Probable human carcinogen.
Hexachlorobutadiene 87-68-3	**0.4**	**0.14**	**0.4**	**0.14**	Kidney damage, possible CNS depression.	Kidneys, liver, CNS		Possible human carcinogen.
Hexachloroethane 67-72-1	**7**	**2.4**	**7**	**2.4**	Vomiting, diarrhea, severe mucosal injury, liver necrosis, cyanosis, unconsciousness, loss of reflexes.	CNS, liver		Possible human carcinogen.
Hexane (n-) 110-54-3	**18**	**5**	**6**	**2**	Nausea, vomiting, abdominal swelling, weakness, dizziness, lightheadedness, headache, loss of coordination, damage to the peripheral nerves.	CNS, peripheral nervous system		About 50 g (10 g/L) may be fatal to humans.
Hexazinone 51235-04-2	**10.5**	**3**	**10.5**	**3**	Vomiting, liver injury.	Liver		A military adjustment factor of 3 has been applied.
HMX 2691-41-0	**7**	**2.3**	**7**	**2.3**	Changes in the blood, methemoglobinemia, liver damage.	Liver, CNS, blood, cardiovascular systems, kidneys, and liver		
Isophorone 78-59-1	**6**	**2**	**6**	**2**	Headache, nausea, dizziness, fatigue, incoordination, malaise, and narcosis.	CNS, liver, kidneys		Possible human carcinogen.

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Isopropyl methyl-phosphonate 1832-54-8	**120**	**40**	**120**	**40**	High concentrations may cause diarrhea, reduced motor activity, lung injury.	Gastrointestinal tract, lungs		A military adjustment factor of 3 has been applied.
Lewisite* 542-25-3	**0.08**	**0.027**	**-**	**-**	Nausea, vomiting, diarrhea, abdominal pain, intense thirst, restlessness, weakness, hypotension, and hypothermia.	Gastrointestinal tract, heart, brain, kidneys		The risk of potentially fatal performance-degrading injury to the gastrointestinal tract increases as the concentration in drinking water increases above 0.08 mg/L.
Lindane 58-89-9 *TB MED 577	**0.6**	**0.2**	**0.6**	**0.2**	Irritability, restlessness, insomnia, anxiety, dizziness, malaise, headache, nausea, fever, cyanosis, vomiting, and loss of muscle coordination; higher exposure can cause muscle spasms, seizures, and convulsions.	CNS, reproductive tract		Increasing susceptibility to nervous system changes may occur at concentrations between 0.6 and 3.5 mg/L. Signs of poisoning begin to develop at 3.5 mg/L. The mean lethal dose is approximately 400 mg/kg (5.6 g/L). Possible human carcinogen.
Magnesium 7439-95-4 *TB MED 577	**100**	**30**	**100**	**30**	Single doses can have laxative effects that can lead to dehydration, with symptoms of discomfort, weariness, apathy, impaired coordination, delirium and heat stroke.	Gastrointestinal tract		Laxative effects occur at doses greater than 480 mg (96 mg/L).
Malathion 121-75-5	**0.3**	**0.1**	**0.3**	**0.1**	Miosis, blurred vision, tearing, increased salivation, weakness, nausea, vomiting, abdominal cramps, diarrhea, giddiness, confusion, loss of muscle coordination, runny nose, headache, chest tightness, difficulty breathing, pulmonary edema, muscle twitching, coma, respiratory distress, cardiac irregularities, and convulsions.	Lungs, liver, CNS, heart acetyl-cholinesterase inhibitor		No effects were seen in volunteers after a single oral dose of 0.84 mg/kg (11.6 mg/L) or repeated doses of 16 mg/day (3.2 mg/L) for 47 days. The fatal dose is believed to be between 350-1000 mg/kg (4.9-14 mg/L).
Maleic hydrazide 123-33-1	**14**	**5**	**14**	**5**	Tremors and muscle spasms.	CNS		
MCPA 94-74-6	**0.14**	**0.05**	**0.14**	**0.05**	Fatigue, weakness, loss of appetite, nausea, vomiting, diarrhea, lethargy, constricted pupils, hypotension, slurred speech, muscle twitches, random jerky movements, paralysis and convulsions; kidney and liver injury, reduced white and red blood cell counts.	CNS, kidney, liver, blood		Ingestion of 250 mg/kg (3.5 g/L) is fatal.

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Methomyl 16752-77-5	**0.1**	**0.03**	**0.1**	**0.03**	Severe headache, nausea, vomiting, diarrhea, abdominal cramps, sweating, salivation, blurred vision, constricted pupils, muscle twitching, incoordination, weakness, difficulty breathing, increased heart rate; liver and kidney damage; changes in electrocardiograph patterns are possible.	CNS, cardiovascular system, liver, kidneys, blood cholinesterase inhibitor		Doses of 12-15 mg/kg (168-210 mg/L) can be fatal.
Methoxychlor 72-43-5	**0.08**	**0.03**	**0.08**	**0.03**	Muscle spasms, trembling, and convulsions; high concentrations may injure the kidney and liver.	CNS, liver, kidneys		Daily doses of 2 mg/kg (28 mg/L) for 6 weeks had no adverse effects in volunteers. The fatal oral dose for humans had been estimated to be 6 g/kg (84 g/L).
Methyl tert-butyl ether 1634-04-4	**33.6**	**11.3**	**33.6**	**11.3**	Low acute toxicity by ingestion.			Possible human carcinogen.
Methyl parathion 298-00-0	**0.4**	**0.15**	**0.4**	**0.15**	Nausea, vomiting, abdominal cramps, diarrhea, salivation, headache, weakness, giddiness, dizziness, runny nose, blurred vision, miosis, cardiac arrhythmias and ischemia, difficulty breathing; muscle twitch, convulsions, liver and kidney damage, coma and respiratory paralysis are possible at high concentrations.	Eyes, CNS, cardiovascular system, liver and kidney, cholinesterase inhibitor		Volunteers receiving oral doses of 22 mg/day (4.4 mg/L) suffered no ill effects. Depression of red blood cell cholinesterase occurred at doses of 30 mg/day (6 mg/L) which was considered to be the level of minimal toxicity. Ingestion of 50 to 200 g (10-40 g/L) has resulted in death; the minimum adult lethal dose by the oral route may be less than 1.84 gm (370 mg/L).
Metolachlor 51218-45-2	**3**	**1**	**3**	**1**	Headache, nausea, vomiting, abdominal cramps, diarrhea, sweating, weakness, anemia, incoordination, CNS depression, dark urine, liver and kidney damage, jaundice, methemoglobinemia, cyanosis, hypothermia, convulsions; affect fertility.	CNS, liver, kidney, blood		Possible human carcinogen.
Metribuzin 21087-64-9	**6.3**	**2**	**6.3**	**2**	CNS depression; thyroid, kidney and liver injury.	CNS, thyroid, kidney, liver		
Molybdenum trioxide 7439-98-7	**0.03**	**0.009**	**0.03**	**0.009**	Weight loss, diarrhea, poor muscle coordination, headaches, muscle or joint aching.	Liver, kidney, blood		

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Naphthalene 91-20-3	**0.74**	**0.25**	**0.74**	**0.25**	Headache, profuse perspiration, confusion, listlessness, lethargy, muscle twitching, coma; nausea, vomiting, abdominal cramps, diarrhea; hemolytic anemia, methemoglobinemia; cataracts, liver and kidney damage.	Eyes, red blood cells, liver, kidney, CNS		Ingestion of 1 g naphthalene (200 mg/L) caused near blindness within 9 hours. The lethal dose is about 2 gm (400 mg/L).
Nickel 7440-02-0	**1**	**0.5**	**1**	**0.5**	Soluble nickel salts may cause gastrointestinal distress, nausea, abdominal cramps, diarrhea, vomiting, giddiness, weariness, and headache; metallic nickel is generally considered not to be acutely toxic if ingested.	Gastrointestinal tract, CNS		
Nitroguanidine 556-88-7	**15**	**5**	**15**	**5**	High concentrations may cause inactivity, incoordination, tremors, difficulty breathing, and cyanosis.	CNS		
Nitrophenol p- 100-02-7	**1.2**	**0.4**	**1.2**	**0.4**	Fever, CNS depression, sweating, weakness, headache, dizziness, tinnitus, irregular pulse, hypotension, shallow respiration, cyanosis.	CNS, blood	Odor: 43.4 mg/L	
Oxamyl [Vydate] 23135-22-0	**0.35**	**0.1**	**0.35**	**0.1**	Tremors, blurred or dim vision, increased salivation, tearing, incontinence, diarrhea, abdominal cramps, nausea, vomiting, and difficulty breathing; convulsions, coma, and respiratory paralysis are possible at high concentrations; protracted malaise and weakness may persist after apparent recovery.			
Paraquat 1910-42-5	**0.14**	**0.05**	**0.14**	**0.05**	Abdominal cramping, nausea, vomiting, bloody diarrhea, headache, difficulty swallowing, fever, decreased blood pressure; higher concentrations can cause heart, kidney and liver injury and extensive lung damage with difficulty breathing, pulmonary fibrosis and edema; may reduce fertility in males.	Lungs, liver, kidney, gastrointestinal tract		Single oral doses of 1 to 4 gm (200 to 800 mg/L) have caused fatalities.
Pentachlorophenol 87-86-5	**1.4**	**0.5**	**0.4**	**0.14**	Weakness, thirst, loss of appetite, vomiting, shortness of breath, chest pain, sweating, headache, dizziness, high fever, hypotension, and gastrointestinal upset; high concentrations may cause lung, liver, and kidney damage and convulsions.	CNS, heart	Odor: 0.03 mg/L	Ingestion of 0.1 mg/kg (1.4 mg/L) caused no effects in volunteers. The minimum lethal dose was estimated to be 29 mg/kg (406 mg/L). Probable human carcinogen.

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Phenol 108-95-2	**8**	**3**	**8**	**3**	Corrosion of the mouth, throat, and stomach, pallor, nausea, vomiting, severe abdominal pain, cold sweats, cardiac arrhythmia, wide fluctuations in blood pressure, respiratory distress, reduced body temperature, circulatory collapse.	Liver, kidneys, cardiovascular system	Odor: 0.3 mg/L	Doses of about 14 mg/kg (200 mg/L) can have dangerous effects. The oral LD_{50} has been estimated to be 140 mg/kg (2 g/L). Phenol can react with the water supply disinfectant hypochlorite to produce objectionable tastes and odors.
Picloram 1918-02-01	**28**	**9.4**	**28**	**9.4**	Nausea, diarrhea, weakness, damage to the CNS.	CNS		
Prometon 1610-18-0	**0.2**	**0.07**	**0.2**	**0.07**	Mild skin and eye irritant.	CNS		
Pronamide 23950-58-5	**1**	**0.4**	**1**	**0.4**	May cause cholestasis (blockage of bile flow in the liver) which can lead to liver damage.	Liver		Possible human carcinogen.
Propachlor 1918-16-7	**0.7**	**0.24**	**0.7**	**0.24**	Weakness, salivation, tremors; liver and kidney injury.	CNS, liver, kidney		
Propazine 139-40-2	**1.4**	**0.5**	**1.4**	**0.5**	Loss of appetite, depression; high concentrations may cause dizziness, cramps and difficulty breathing.	CNS, blood, liver		Possible human carcinogen.
Propham 122-42-9	**7**	**2**	**7**	**2**				
RDX 121-82-4	**0.14**	**0.05**	**0.14**	**0.05**	Headache, irritability, fatigue, weakness, tremor, nausea, vomiting, dizziness, confusion, amnesia, insomnia, convulsions, liver injury.	CNS, liver		Possible human carcinogen.
Silver 7440-22-4	**0.07**	**0.023**	**0.07**	**0.023**	High concentrations may cause abdominal pain, diarrhea, vomiting, corrosion of the gastrointestinal tract, shock and convulsions.	Skin, eyes, CNS		A single oral dose of 140 mg/kg (2 g/L) may be fatal.
Simazine 122-34-9	**0.03**	**0.01**	**0.03**	**0.01**	Incoordination, tremor, weakness, muscle spasms, difficulty breathing.	CNS, kidneys, liver		Possible human carcinogen.
Strontium 7440-24-6	**36**	**12**	**36**	**12**	Excess salivation, vomiting, colic, and diarrhea.	Bone		
Styrene 100-42-5	**30**	**10**	**3**	**1**	Headache, fatigue, dizziness, confusion, malaise, drowsiness, weakness, unsteady gait, impaired manual dexterity, loss of concentration.	CNS		Possible human carcinogen.

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Sulfate *TB MED 577	**300**	**100**	**300**	**100**	Single doses can have laxative effects which can lead to dehydration, with symptoms of discomfort, weariness, apathy, impaired coordination, delirium.	Gastrointestinal tract		Laxative effects occur at doses greater than 1490 mg (300 mg/L).
Sulfur mustard [HD] 505-60-2 *TB MED 577	**0.14**	**0.047**	**-**	**-**	Nausea, vomiting of blood, diarrhea, abdominal pain, fever, headache, cardiac arrhythmias, dizziness, malaise, loss of appetite, lethargy, convulsions, leukopenia, anemia, immunosuppression.	Gastrointestinal tract, CNS, blood		The oral LD_{50} for humans has been estimated to be 0.7 mg/kg (9.8 mg/L). Known human carcinogen.
2,4,5-T [Trichlorophenoxy-acetic acid] 93-76-5	**1**	**0.4**	**1**	**0.4**	Chloracne, nausea, headache, fatigue, muscular aches and pains; may affect the developing fetus.	Skin, reproductive system		The only symptom reported after ingestion of 5 mg/kg (70 mg/L) was a metallic taste in the mouth.
T-2 toxin 21259-20-1 *TB MED 577	**0.026**	**0.0087**	**-**	**-**	Nausea, vomiting, diarrhea, generalized burning erythema, mental confusion.	Gastrointestinal tract, CNS		Nausea and vomiting can be expected to occur at a concentration of 0.05 mg/L. The most severe effects, including gastrointestinal problems, diarrhea, generalized burning erythema, and mental confusion, occur at a concentration of 0.78 mg/L.
TCDD (2,3,7,8-) 1746-01-6	**1E-06**	**5E-07**	**1E-07**	**5E-08**	Headache, nausea, vomiting, severe muscle pain, liver damage, chloracne, porphyria cutanea tarda, hair loss, hyperpigmentation, polyneuropathy, neurobehavioral effects, possible immunosuppression, thymic atrophy.	Liver, skin, kidneys, blood, reproductive system		Human lethal doses have been estimated to be greater than 100 µg/kg (1.4 mg/L). Probable human carcinogen.
Tebuthiuron 34014-18-1	**3.5**	**1**	**3.5**	**1**	Reversible pancreatic changes.	Pancreas		
Terbacil 5902-51-2	**0.35**	**0.1**	**0.35**	**0.1**	Pallor, prostration, vomiting, and rapid respiration.	Liver		

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Terbufos 13071-79-9	**0.007**	**0.002**	**0.007**	**0.002**	Nausea, vomiting, abdominal cramps, diarrhea, excessive salivation, headache, dizziness, weakness, excessive tearing and salivation, ocular pain, blurred vision, constricted pupils, incoordination, slurred speech, muscle twitches, mental confusion, drowsiness, difficulty breathing, cyanosis, cardiac irregularities, incontinence, convulsions, and coma.	CNS, cardiovascular system, blood cholinesterase inhibitor		
Tetrachloroethane (1,1,1,2-) 630-20-6	**3**	**1**	**3**	**1**	Weakness, fatigue, nausea, headache, incoordination; liver injury, decreased red blood cell counts, increased percent of large mononuclear cells in blood.	CNS, liver blood		Possible human carcinogen.
Tetrachloroethylene 127-18-4	**2.8**	**0.9**	**2.8**	**0.9**	Nausea, dizziness, incoordination, headache, sleepiness, liver damage.	Liver, CNS		
Thallium 7440-28-0	**0.01**	**0.003**	**0.01**	**0.003**	Metallic taste in the mouth, fatigue, anxiety, irritability, gastroenteritis, diarrhea or constipation, vomiting, abdominal pain, chest pain, paresthesia of the hands and feet, tremor, convulsions, pain and loss of muscle strength in the limbs, hair loss, vision loss; damage to the lungs, kidneys, and nervous system; hypertension, EKG changes and other cardiovascular effects.	Eyes, CNS, peripheral nervous system, gastrointestinal tract, lungs, liver, kidneys, body hair		An oral dose of 3.4 mg/kg (48 mg/L) produced chest pain, vomiting, paresthesia of the hands and feet, and weakness; 7 mg/kg (100 mg/L) may be fatal. Symptoms of acute exposure are typically delayed hours to days.
Toluene 108-88-3	**30**	**10**	**3**	**1**	Fatigue, nausea, weakness, confusion; higher concentrations can cause headache, vomiting, diarrhea, depressed respiration, loss of muscle coordination.	CNS	Odor: 0.04 – 1 mg/L	
2,4,5-TP 93-72-1	**0.3**	**0.09**	**0.3**	**0.09**	Fatigue, weakness, nausea, vomiting, abdominal pain, diarrhea, muscle twitching, weakened reflexes, constricted pupils; high concentrations can produce profuse sweating, hypotension, painful neuritis, metabolic acidosis, fever, rapid heart beat, hyperventilation, and coma.	Liver, kidney, CNS		

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Trichloroacetic acid 76-03-9	**5.6**	**1.9**	**5.6**	**1.9**	Gastrointestinal disturbances, acidosis, vomiting, diarrhea, and lassitude; decreased plasma lactate and glucose levels, and hypotension; high concentrations may cause CNS depression.	Gastrointestinal tract, liver, kidney		Possible human carcinogen.
Trichloroacetonitrile 545-06-2	**0.07**	**0.023**	**0.07**	**0.023**				
Trichlorobenzene (1,2,4-) 120-82-1	**0.2**	**0.06**	**0.2**	**0.06**	Lethargy, incoordination, changes in liver, kidneys and adrenal glands.	Liver, kidneys, adrenal glands		
Trichlorobenzene (1,3,5-) 108-70-3	**0.8**	**0.3**	**0.8**	**0.3**	Lethargy, incoordination, changes in liver, kidneys, and adrenal glands.	Liver, kidneys, adrenal glands		
Trichloroethane (1,1,1-) 71-55-6	**140**	**50**	**60**	**20**	Headache, weakness, dizziness, increased reaction time, impaired judgment; high concentrations can cause severe vomiting and diarrhea, cardiac arrhythmias and liver damage.	CNS, cardiovascular system, liver		Exposure to about 600 mg/kg (8.4 g/L) can cause incapacitating vomiting and diarrhea.
Trichloroethane (1,1,2-) 79-00-5	**0.8**	**0.3**	**0.5**	**0.2**	Headache, weakness, dizziness, nausea, vomiting, and diarrhea; drowsiness, loss of coordination and judgment; possible liver and kidney damage.	CNS, liver, kidneys		Possible human carcinogen.
Trichloroethylene** 79-01-6	**2.8**	**0.9**	**2.8**	**0.9**	Headache, dizziness, blurred vision, fatigue, giddiness, tremor, sleepiness, nausea, vomiting, abdominal pain, cardiac arrhythmias, mild liver dysfunction; may cause birth defects.	CNS, heart, liver, kidneys, reproductive system		Doses of 21 to 35 g (4.2 - 7 g/L) can cause vomiting and abdominal pain followed by transient unconsciousness. Probable human carcinogen.
Trichloropropane (1,2,3-) 96-18-4	**0.8**	**0.3**	**0.8**	**0.3**	CNS damage, liver and kidney changes, lethargy, cardiovascular abnormalities.	CNS, liver, kidney, cardiovascular system, blood		Probable human carcinogen.
Trifluralin 1582-09-8	**0.1**	**0.04**	**0.1**	**0.04**	Liver and kidney changes, anemia, CNS depression.	CNS, liver, kidney, blood		Possible human carcinogen.

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Trinitroglycerol 55-63-0	**0.007**	**0.002**	**0.007**	**0.002**	Severe throbbing headache, nausea, hypotension, light-headedness; high exposure can cause flushing of the face and neck, vomiting, dizziness, delirium, confusion, methemoglobinemia, hallucinations, and difficulty breathing.	Cardiovascular system, blood, CNS, testes		Doses of 0.15 to 0.6 mg (0.03-0.12 mg/L) affect the cardiovascular system causing vasodilation and general relaxation of the smooth musculature.
Trinitrotoluene (2,4,6-) 118-96-7	**0.025**	**0.008**	**0.025**	**0.008**	Red pigmentation in the urine, abdominal pain, methemoglobinemia, anemia, ataxia, cyanosis, tremors; high concentrations may cause convulsions; liver damage, gastrointestinal tract irritation; male reproductive effects.	Liver, blood, gastrointestinal tract, CNS		Possible human carcinogen.
Vinyl chloride 75-01-4	**3.6**	**1.2**	**3.6**	**1.2**	Headache, dizziness, loss of muscle coordination, inebriation, euphoria, fatigue, numbness and tingling of the extremities, drowsiness, and visual disturbances.	CNS		Known human carcinogen.
VX 50782-69-9 *TB MED 577	**0.015**	**0.005**	**-**	**-**	Nausea, vomiting, diarrhea, abdominal cramps, headache, giddiness, dizziness, excessive salivation, tearing, miosis, blurred or dim vision, miosis, difficulty breathing, cardiac arrhythmias, loss of muscle coordination, muscle twitching, random jerking movements, convulsions, coma.	CNS, cholinesterase inhibitor		Single oral doses of 0.002 to 0.0045 mg/kg (0.028-0.063 mg/L) caused gastrointestinal effects in 5/32 volunteers; repeated doses of 0.00143 mg/kg/day (0.02 mg/L/day) in the drinking water 4 times/day for 7 days caused no effects. The human oral LD_{50} value has been estimated to be 0.0075 mg/kg (0.11 mg/L).
Xylenes 1330-20-7	**60**	**20**	**60**	**20**	Headache, weakness, dizziness, confusion, nausea, vomiting, abdominal pain, shivering, incoordination, loss of appetite, tremors, disturbed vision, salivation, and difficulty breathing; liver and kidney damage, and cardiac arrhythmias are possible.	CNS, liver, kidneys, blood, gastrointestinal tract	Odor: 0.3 – 1.0 mg/L	The lowest oral lethal dose was reported to be 50 mg/kg (700 mg/L)

Compound	5-day (mg/L) 5 L	5-day (mg/L) 15 L	2-week (mg/L) 5 L	2-week (mg/L) 15 L	Potential Toxic Signs and Symptoms	Target Organ	Odor and Taste Threshold	Notes
Zinc chloride [measured as Zinc] 7646-85-7	**8**	**3**	**8**	**3**	Severe stomach irritation, nausea, vomiting, and diarrhea.	Gastrointestinal tract		

Notes:
This table contains short-term exposure guidelines (MWGs-S) for drinking water contaminants for 5-day and 2-week exposures at two rates of water consumption: 5 liters per day and 15 liters per day. In temperate conditions, the estimated rate of consumption is 5 liters/day. In arid regions, the estimated rate of consumption is 15 liters/day.

The sources for odor and taste thresholds in water were the U.S. Environmental Protection Agency *Health Advisory* for individual chemicals and the National Library of Medicine's Hazardous Substance Database (HSDB).

The notes column shows estimated oral doses that can cause the toxic effects indicated when available. The reported doses were converted into mg/L concentrations in water (shown in parentheses) for 5 L/day consumption rates. Divide by 3 to convert to 15 L/day consumption rates. Estimated lethal doses and approximate toxic effect levels were obtained from the TOMES database software system, from Gosselin et al. (1976), from Hayes, Pesticides Studied in Man and from the EPA Health Advisory Source documents .

* These values were taken from TB MED 577.
** These values were derived from the ATSDR acute oral MRLs.
*** EA 2192 is a breakdown product of VX. Because its toxicity is believed to be similar to that of VX, the TB MED 577 standard for VX was applied to EA 2192.
**** Atrazine values were adjusted in accordance with the 4/01/97 IRIS record.

CNS – Central Nervous System.

APPENDIX E

DATA EVALUATION EXAMPLES

Introduction

The examples provided in this section are theoretical scenarios that demonstrate examples of the thought process that may be followed in different deployment situations. They do not establish the *only* way risk decisions should be made. Instead, they portray some of the different considerations military health services personnel may have to consider when evaluating health risks from chemical exposures. Finally, the examples demonstrate how the information in this TG can be tied into the implementation of FM 100-14, *Risk Management*.

Scenarios Include:

1. Field Assessment – Operations Other than War; Multiple Exposures
2. Wartime - less than critical vs. catastrophic hazards; equipment/public considerations
3. Peacekeeping - 1-hour peaks; NAAQS, exceeding duration periods
4. Drinking Water - TB MED standards vs. non-TB Med standards; severity
5. Drinking Water - Chemical Exposures vs. Dehydration
6. Drinking Water - Treatment with ROWPU
7. Occupational Hazards - Other evaluation guidelines

The following matrix should be referred to in the process of assessing and communicating risk associated with chemical exposures. In particular, severity of the health risk associated with an exposure to a given chemical concentration should be categorized as Negligible, Marginal, Critical, or Catastrophic. The probability is the likeliness that you anticipate that degree of severity (which is dependent on both the concentration and exposure time) will in fact occur to an entire population (e.g. unit) of concern. Probability is ranked in the order of frequent to unlikely as described below.

RISK ASSESSMENT MATRIX

	PROBABILITY				
SEVERITY	**Frequent**	**Likely**	**Occasional**	**Seldom**	**Unlikely**
Catastrophic	E	E	H	H	M
Critical	E	H	H	M	L
Marginal	H	M	M	L	L
Negligible	M	L	L	L	L

E - Extremely High Risk
H - High Risk
M - Moderate Risk
L - Low Risk

Figure 3 - Risk Management (FM 100-14, *Risk Management*)

SCENARIO 1: FIELD ASSESSMENT DURING NON-WARTIME MISSION

You are deployed on a peacekeeping mission. You accompany an infantry company which will be performing a border recon/security mission. It is undetermined at this time how long the mission will last, although approximately 2 weeks is anticipated. A temporary base camp must be established for the recon team; "Site X" is determined to be a particularly ideal location. Part of the mission is to evaluate its suitability as a more permanent base camp for future activities.

Your Preventive Medicine responsibilities require you to assess the potential health risks to the military personnel from environmental contaminants at "Site X". The team is carrying limited supplies in order to maneuver quickly. This includes three days of drinking water. Therefore, your primary task includes assessing the suitability of a drinking water source or determining if additional bottled water supplies are needed. In addition, you must evaluate other environmental conditions that could result in adverse health impacts to your team or to other personnel who may eventually be deployed to the area.

Your evaluation of the potential health risks should follow the process described in FM 100-14. Your commanding officer will then have to balance these potential health risks with other risks such as logistical obstacles and physical hazards in order to make appropriate decisions regarding the recon mission as well as future deployments into the area.

First - You consider all <u>general information</u> immediately available:

Site X is near a town. There are some indications of industrial activity including abandoned structures. You notice a slight chemical odor around the side of one structure. A municipal water supply is identified in one of the structures; however, a member of the recon team tastes the water and notes that it has a slight fuel-like taste, although there is no odor.

Second - You obtain pertinent <u>sampling data</u> as are required and/or practicable:

Three air monitoring samples are obtained from around the site (including the location where an odor is noticed) and samples analyzed using available onsite-field equipment.

Using the kits in your Water Quality Analysis Set-Preventive Medicine (WQAS-PM), you check the bottled water being used by the team in accordance with TB MED 577, *Sanitary Control and Surveillance of Field Water Supplies*. You determine that the physical and chemical properties measurable by the kits in your WQAS-PM are within the Tri-Service Standards listed in the Appendices of TB MED 577. Because of the strange taste in the bottled water, you collect three samples and send them for rear-area analysis at a supporting medical laboratory. The results of the water analysis may not be available for up to seven days.

SCENARIO 1: Part A – Water Evaluation

Initial assessment:

Since the water meets the Tri-Service Standards and, given the 14-day anticipated mission and the existing 3-day water supply, you do not anticipate any critical or catastrophic health effects associated with drinking the available water source. However, you note that due to the fuel-like taste, personnel may drink less than optimum amounts of water. In addition, the results of rear-area analysis may determine that the fuel-like taste may be from other contaminants that have some associated health effects. Considering the severity categories described by FM-100-14, you rank this as *marginal* risk severity. From your past experiences, you feel fairly certain that personnel will drink less. You also feel certain that the analysis will identify some contaminants, but you doubt that the concentrations will be at levels constituting a critical or catastrophic health risk for less than 14 days of consumption. Therefore, you feel that the probability of these marginal health risks is likely. Per the FM 100-14, *Risk Assessment Matrix*, you establish that the overall risk level is *moderate*.

You inform your commander and are informed that on the basis of your input and other risks, it is decided that no additional bottled water will be requested for the 14-day recon mission. Decisions regarding potential future use of the water source will be deferred pending receipt of rear-area results.

Follow-up assessment:

After six days you obtain the results of the water analysis. The results indicate benzene was present at 0.9 mg/L. The steps below describe how you might evaluate the data and reassess the risks.

Single Contaminant Evaluation:

1. Refer to Appendix D and locate the compound. Note that for both *Temperate Climate* (5 L/day consumption) and *Arid Climate* (15 L/day consumption), the measured benzene concentration exceeds the 5-day and 14-day guidelines. The benzene-contaminated water may produce some adverse non-carcinogenic effects. The "Notes" column in Appendix D indicates that benzene can have long-term carcinogenic effects and that benzene can impart a taste/odor to drinking water. The absence of asterisks next to benzene in the compound column of Appendix D indicates that the 5-day and 2-week values came from the short-term exposure criteria in the EPA Health Advisory for benzene. There are no Tri-Service Standards in TB MED 577 for benzene.

2. You don't expect any odor to come from the water due to the benzene, since odor from benzene in water is not expected unless benzene concentrations are near or above 2 mg/L. The benzene in the water may impart a taste since the measured concentration of benzene is in the taste threshold range of 0.5 - 4.5 mg/L. Note that the odor and taste thresholds of benzene in drinking water are well above the guideline values at which no significant adverse health effects are expected.

3. You consider that the fuel-like taste disappeared after the first day of use and that the weather has been comfortable, so the consumption rates of personnel were probably under 5 L/day. You conclude that the risk level of moderate is still justified for this recon mission. In order to provide information for future, potential longer deployments to the area, you recommend another water sample be obtained for rear-area analysis to determine whether the benzene levels have in fact dropped.

SCENARIO 1: Part B - AIR EVALUATION

The air screening analysis identifies the following compounds at the concentrations shown:

	Sample 1	**Sample 2**	**Sample 3**
Acrylonitrile	0.01 mg/m^3	0.02 mg/m^3	0.01 mg/m^3
Aldrin	0.25 mg/m^3	0.009 mg/m^3	0.20 mg/m^3
Benzene	32.0 mg/m^3	156 mg/m^3	2.0 mg/m^3

The following phased process describes how one might assess potential health risks should camp be established at this site:

Single Contaminant Evaluation:

Begin with the compound **ACRYLONITRILE**.

1. Refer to Appendix C and locate the compound.

2. Note that the MAG-S listed for up to a continuous 14-day exposure is 0.22 mg/m^3.

3. Since all three of the sample concentrations are below the limit, it may be presumed that risk from acryonitrile alone is of *negligible severity*. This would apply to exposures from 1 hour up to 14 days.

4. Next, repeat the same process for **ALDRIN**. Note that one sample concentration is at the 1- to 14-day MAG-S level of 0.25 ppm, while the rest are below that level. Since exposures equal to or less than the MAGs-S are not expected to cause health effects, one may still assume that health risks associated with this compound are *negligible*.

5. Finally, check Appendix C for **BENZENE**. Note that MAGs-S are provided for different exposure duration. Since all of the sample data exceed the 1-14-day MAGs-S, there may be some adverse health impacts associated with the presence of the contaminant at this site. You consider how to determine the severity of the risk associated with these concentrations. In addition, you must consider the probability of exposure to that risk over the 14-day duration.

6. To assess the types of symptoms and/or toxicological endpoints caused by exposures to benzene, refer to Appendix C. Potential effects include headaches, weakness, nausea, eye, skin, nose, and respiratory irritation. It is also noted that benzene is a carcinogen. You determine that the severity associated with the detected concentrations is at least marginal and possibly critical. However, you feel that the hazard is localized around the one structure and that personnel will only occasionally or seldom have to spend any amount of time there. Using the FM 100-14, *Risk Assessment Matrix*, you, therefore, conclude that the health risk level associated with air hazard is *moderate* to *low*.

7. As a precaution, you also decide to recommend to your commander that personnel be warned to stay away from the area and that some flags be posted as warning.

SCENARIO 1: Part C - Multiple Exposures

Thus far, in Scenario 1, assessments have been performed by evaluating individual media and individual contaminants. Health effects may, however, result from a combination of exposures. While there is limited information regarding interactions of different chemicals, the information provided in the scenario above can be used to identify potential exposures that may have additive effects.

Multiple Contaminant:

Your investigation has identified three airborne contaminants, yet only one appeared to be of concern due to exceeding the MAGs-S. However, since certain contaminants may have similar adverse effects within the body, it is necessary to consider the sum total of all like effects. For example:

1. In Appendix C, the symptoms/toxic endpoints associated with acrylonitrile and aldrin are similar (i.e., they are skin irritants and are also both noted as carcinogens). As noted previously, benzene is also identified as a skin irritant and carcinogen.

2. While acrylonitrile and aldrin individually did not appear to pose a health risk, they may actually exacerbate the potential risks posed by benzene. Though this cannot be quantified, you should consider it in the overall assessment of the conditions at the site.

Multiple Exposure Pathway:

1. In addition to evaluating the different contaminants in air, some consideration should be given to the potential additive effects of being exposed to the same or similar compounds through *both* air and water. As described above, you should determine whether there are compounds with similar effects (in both air and water).

2. You note that benzene was present in both air and water samples.

SCENARIO 1: Part D – Conclusions

The combination of exposures to the three contaminants from air and water at the reported concentrations indicate that some minimally adverse, non-carcinogenic effects may occur in members of the recon team. You believe that you have controlled exposure to significant concentrations either by controls or naturally (diminished taste in drinking water). However, given the potential additive effects through multiple exposure pathways and chemicals, you do not believe that risk has been eliminated. You again estimate a *moderate risk level*.

Potential Recommendations/Actions:

In the cited example, immediate decisions required your evaluation of potential health hazards. In addition to estimating a risk level, your duties also involve suggesting control/ countermeasures. This could have included locating the camp to another site, modifying the current camp set-up to minimize accessibility to specific areas of concern and requesting a different source of drinking

water. In cases where conditions change, such as the duration of the mission is extended, a re-evaluation of the data and new recommendations may be necessary.

In this example, you are asked about your opinions regarding future (potentially longer) missions to the area. You have already requested additional analyses of the water supply. You feel that the air hazard is localized and controllable. You document this information and provide it to your commander.

SCENARIO 2: WAR-TIME OPERATION

You are the preventive medicine officer located at a central base camp during a wartime mission. Your responsibilities include transferring information to/from the field units in your area and making recommendations to higher headquarters. You have just received intelligence information about a factory located in proximity to one of your units. The intelligence information includes the following:

- *Various chemicals are stored at the factory; of particular concern is **CHLORINE**.*
- *Large amounts (tons) are stored, but it appears the plant is not operational.*
- *Enemy troops are aware of the unit's location.*

First:

You realize that the stored chlorine could be used purposefully against U.S. personnel through bombing or other mechanisms resulting in the release of chlorine. You check Appendix C and establish the effects associated with this compound (burning of eyes, nose, and respiratory system. More serious effects include coughing, choking, and vomiting).

Next:

You need to notify the unit of the situation. You realize that the commanding officer will want some estimate of the level of risk. Currently, you have limited information as to both the anticipated concentrations (severity of risk) as well as the probability that a release would even occur. As an initial assessment, you use professional judgement to estimate a *high* to *extremely high-risk level* (*severity range either marginal/critical/catastrophic; probability range occasional/likely*).

You notify the unit of your assessment and verify the unit's exact location and number of personnel. A decision is made to have the unit retreat back.

Later:

You receive word that during the retreat back to base camp, the factory was bombed. Personnel had already retreated (downwind) approximately one-half mile when the incident occurred. The commander of the unit has halted the retreat and is asking if the unit should prepare to turn back. The success of the mission requires movement forward, and since the hazard has been mitigated it would be an opportune time to proceed. You caution the commander that residual contaminant might present a hazard.

The commander informs you that he has already dispatched a member of his unit with sampling equipment and protective gear to obtain real-time data from the area. He returns with data indicating levels of chlorine around 4 ppm (10 mg/m^3).

You check Appendix C of the TG. You determine this to be just above the 1-hour MAG-S level for a significant effects level (3 ppm) (but below the severe effect level MAG-1, 20 ppm). You determine this to be a *critical degree of severity*. However, you consider that it is probable further dissipation of the chemical will have occurred by the time the unit gets to the area. The unit will be moving through the area of concern rapidly, which may mean less than a full hour of exposure (though you realize that there will be heavy exertion and increased breathing involved). You conclude that the *probability* of a critical risk may be *likely* to *occasional*. In all, you still estimate a *high risk level* and note that, while you did not anticipate deaths associated with exposure to the chemical, other significant health effects may inhibit the ability of personnel to quickly maneuver through the area. You also note that, if personnel were to be detained in the area for an extended period (beyond 1 hour), the conditions could worsen. However, if personnel pass through the area quickly, any signs and symptoms that occur will likely cease once exposure is eliminated.

You discuss the options with the unit commander. This includes:

- waiting (and later reanalysis);
- choosing an alternate route circumventing the area of concern;
- providing protective gear to personnel as they move through the area; or
- accepting the risk of potential health effects to some/ all personnel.

The commander considers risks associated with these options. Option 1 is not acceptable because of the delayed time, unsafe environment (from enemy ambush), and unknown outcome of additional analysis. Extending the mission with delays was also going to drain supplies/ resources. Option 2 had similar disadvantages. While protective gear was available to personnel, Option 3 would inhibit movement and add to overall fatigue and potential heat stress. In addition, such protective gear imparted other serious disadvantages such as reduced visibility and communication capabilities. Therefore, the commander selects Option 4 with the full knowledge of the types of signs/symptoms associated with exposure to the chlorine gas. His next step is to communicate this risk to his staff.

SCENARIO 3: GENERAL AIR QUALITY, PEAK CONCENTRATIONS; EXCEEDING DURATION PERIODS

You are assisting with setting up a base camp for a peacekeeping operation. You notice heavy smog emanating from the nearby city. The base camp itself is on part of an old mining facility.

As part of your preventive medicine duties, you assist with monitoring and sampling procedures. You have been asked to obtain data on specific criteria pollutants as is done in the U.S. to evaluate the overall quality of the air. In addition, you are assessing the potential for any adverse health effects for the personnel deployed to this area. The initial unit is scheduled to leave after camp is established (about 2 weeks). You realize that follow-up personnel may end up spending up to a year at this location.

Your first round of sampling/monitoring provides the following data:

	Sample 1 Time 0900	**Sample 2** Time 1200	**Sample 3** Time 2000
Sulfur Dioxide (SO_2)	0.4 mg/m^3	1.3 mg/m^3	0.5 mg/m^3
Particulate	150 mg/m^3	270 mg/m^3	254 mg/m^3

SO_2:

The 1-hour MAG-S does not include a *minimum effect level*. You note that you do not exceed the *significant effect level* but exceed the 1-14 day level in the sample taken at 1200. You realize that you may have "peaks" in which this value is exceeded, but on average you feel that the concentrations will be below the 1-14 day guidelines. You read in the "Notes" column of Appendix C that this compound may have some metallic taste associated with it at certain peak concentrations. This, however, is not a particular health concern. The health effects of concern would be irritation of the mucous membranes (e.g., eyes, throat) as well as coughing. Given the concentration levels and the types of effects, you, therefore, ascertain the presence of SO_2 to be a relatively *negligible severity* of risk.

Particulate:

Though there is no MAG-S for Particulate, you refer to Section 4.5 of the TG to compare with U.S. general population guidelines. You note that the detected values are in the range that may produce potential respiratory symptoms such as coughing in particularly sensitive persons such as

those with asthma, or in the case of a civilian population the elderly or children. You note that physical activity can increase some of the minor effects even in a healthy population. You note this as a *marginal level of severity* for a 2-week period.

The SO_2 levels slightly exceed the 1-14 day MAG-G. You again would also classify this as a *marginal level of severity* for a 2-week period.

Given the anticipated fluctuations in concentrations, you feel that the probability of being at a marginal severity level is occasional to seldom. This results in an overall risk level of *low* to *moderate*.

Regarding future deployments of up to 1 year, you are not sure what the extended duration might mean regarding the *severity* of effects associated with these concentrations. You refer to USACHPPM TG 230B, *Long-Term Chemical Exposure Guidelines for Deployed Military Personnel.*

SCENARIO 4 - DRINKING WATER – TB MED STANDARDS VERSUS MWGs-S

You have obtained three water samples from your original drinking water source, suspecting sabotage with nerve agent. It's a rather warm arid climate and you anticipate consumption rates up to 15 L/day. Anticipating the potential need for an alternative, you also obtain three samples from each of two other existing sources - one which appears to be contaminated through pollution. Your results indicated the presence of VX in the original source, arsenic in the first alternative sources, and chlorobenzene, phenol, and benzene in the second alternative source. The data obtained from the original source are as follows:

ORIGINAL SOURCE:

	Sample 1	**Sample 2**	**Sample 3**
Nerve Agent (e.g. VX)	0.02 mg/L	0.03 mg/L	0.02 mg/L

These data confirm your suspicions about your original source; residual nerve agent was detected. Since your detection capabilities cannot tell you specifically which nerve agent is present, you assume the worst case and check Appendix D for VX. You note that concentrations are above the MWGs-S of 0.015mg/L and 0.005 mg/L for consumption rates of 5 and 15 L/day, respectively. You note these MWGs-S are in fact TB MED 577 standards and should not be exceeded. You read the side notes in Appendix D and learn that consumption of VX-contaminated water at the rate of 5 L/day for up to 7 days can cause a toxic response of the following severity (as stated in the footnote to the Table, all the doses in the "Notes" column of Appendix D are for consumption rates of 5 L/day):

> **VX** – *MWGs-S = TB MED standard = 0.015 mg/L and 0.005mg/L for consumption rates of 5 and 15 mg/L/day;*
>
> *Minimal to no effects – 0.02 mg/L/day (consumption rate 5 L/day) for 7 days;*
>
> *Lethal dose – 0.11 mg/L (consumption rate 5 L/day).*

Since you anticipate a consumption rate of 15 L/day, you must divide the above concentrations for the 5 L/day consumption rate by 3 to achieve similar "minimal to no effects" and "lethal" risk levels. Doing this, the "minimal to no effects" and "lethal" risk levels become 0.0067 mg/L and 0.037 mg/L, respectively.

On the basis of this information, you estimate the severity level associated with this source as *critical* to *catastrophic* as described in Figure 3, *Risk Assessment Matrix*. This estimation reflects your particular concern regarding the small difference between a "safe" level and a "lethal" level. This small difference (referred to as a steep dose-response curve) means that a minor fluctuation in concentration can have catastrophic effects.

ALTERNATE SOURCE NO. 1

	Sample 1	**Sample 2**	**Sample 3**
Arsenic	0.4 mg/L	0.3 mg/L	0.4 mg/L

You are surprised to find arsenic in your first alternative water source. In particular, the concentrations are, again, above the MWGs-S. For this compound, too, the MWGs-S are actually TB MED standards.

> **Arsenic** - *MWGs-S = TB MED standard = 0.3 and 0.1 mg/L for consumption rates – 5 and 15 L/day;*
>
> *Acute toxicity – Toxic at doses above 0.1 mg/L (consumption rate - 15 L/day); Severely toxic or fatal at concentrations greater than 4.7 mg/L (consumption rate – 15 L/day).*

On the basis of this information, you estimate the severity level associated with this source as *marginal* to *critical.*

ALTERNATE SOURCE NO. 2

	Sample 1	**Sample 2**	**Sample 3**
Chlorobenzene	0.6 mg/L	1.5 mg/L	1.0 mg/L
Phenol	2.4 mg/L	3.2 mg/L	1.7 mg/L
Benzene	0.07 mg/L	0.3 mg/L	0.17 mg/L

You had predicted that the second alternative had some contamination due to the odor. This source also exceeded the MWGs-S for detected contaminants. You obtain additional information from the notes sections in Appendix D including the following:

Chlorobenzene – *MWGs-S = 3 and 1 mg/L for 5 and 15 L/day, respectively;*

Taste and odor thresholds = 0.01 and 0.05 mg/L, respectively.

Benzene – *MWGs-S = 0.3 and 0.1 mg/L for 5 and 15 L/day, respectively;*

Mean lethal dose = approximately 867 mg/L (consumption rate 15 L/day).

Phenol – *MWGs-S = 8 and 3 mg/L for consumption rates of 5 and 15 L/day, respectively;*

Acute toxicity – 67 mg/L can have dangerous effects and 667 mg/L can be lethal (consumption rate 15 L/day);

Odor threshold = 0.3 mg/L.

The odor you noticed is consistent with the findings. (Note that the odor thresholds are surpassed for both chlorobenzene and phenol.) You are concerned that all compounds exceed the MWGs-S, but you realize that the information you have does not clearly indicate how severe these exceedances might be. (The MWGs-S are only exceeded for 1 of 3 samples for chlorobenzene and phenol and for 2 of 3 samples for benzene if the consumption rate is 15 L/day; if you average the 3 water samples, the MWG-S is only exceeded for benzene at that consumption rate). You do note that the level for benzene is considerably below lethal levels and that the level for phenol is considerably below that which will cause dangerous effects. You also note that two of these compounds have potential effects on the CNS and two can cause liver and kidney damage so you consider potential additive effects.
Overall, you rank this source as *negligible to marginal severity*.

In conclusion, you determine that bottled water is the preferred choice, but given no immediate access to a bottled supply, interim use of the ALTERNATE 2 source would be the next option assuming that each exposure scenario has *equal probability* of occurring. This is in part due to the fact that the other sources exceed TB MED standards which, unlike the MWGs-S derived from other sources, have no built-in margin of safety. Thus, slight excesses beyond the MWGs-S derived from TB MED standards may cause health effects; whereas, the other MWGs-S have a tenfold margin of safety designed to protect more sensitive members of the human population**.**

SCENARIO 5 - DRINKING WATER: CHEMICAL EXPOSURE VERSUS DEHYDRATION

An early insertion team will carry hand-held water treatment devices into their phase of a deployment, intending to use local surface waters as a source of drinking water for several weeks. You learn that the surface waters they intend to use have chloride concentrations around 1200 mg/L. The planner for the early insertion operation wants to know if that will be a problem for his troops.

Single Contaminant Evaluation*:*

1. You refer to Appendix D. Deployed personnel can drink water every day with chloride concentrations up to 600 mg/L in any climate for up to 2 weeks. About 2% of those personnel can be expected to decline to drink the water and to consequently be at increased risk of dehydration.

2. In the Compound column: You note a single asterisk following chloride that indicates that the guideline came from the Tri-Service Field Drinking Water Standards (TB MED 577).

3. You know that chlorides produce a salty or metallic flavor in water that becomes greater with increasing chloride concentrations.

4. You get more details by referring to the Tri-Service Drinking Water Standards (TB MED 577). At the Tri-Service Standard of 600 mg/L, about 2% of deployed military personnel can be expected to decline to drink the water and to be at risk of dehydration. Dehydration symptoms can include weariness, apathy, impaired coordination, delirium, and heat stroke. Above the standard, there is increasing risk that non-acclimated deployed military personnel might initially experience laxative effects. As chloride concentrations reach 900 mg/L, approximately 7% of the deployed force might refuse to drink the water and become susceptible to dehydration. At chloride concentrations around 1200 mg/L, about 18% of the deployed force might refuse to drink the water and become susceptible to dehydration. At chloride concentrations around 1500 mg/L, about 36% of the deployed force might refuse to drink the water.

General Conclusions*:*

At 1200 mg/L chlorides, as much as 18% of the early insertion team may decline to drink the surface water because of objectionable taste, since the hand-held water treatment devices will not remove chlorides from the water. Those team members who find the taste too objectionable will probably begin to dehydrate if another source of fluid is not readily available. As their

dehydration increases, their ability to perform will be at increasing risk of deterioration. The risk of heat stroke also increases, especially if the early insertion team has a high workload and team members are carrying heavy loads.

Using this information and your professional judgment regarding your situation, you estimate that the severity of the associated health risk of relying on such a drinking water source is *marginal* to *critical* and the *probability* of exposure resulting in such effects is *likely*. This results in an estimate of *moderate* to *high degree* of risk.

SCENARIO 6: TREATMENT OF DRINKING WATER

You are deployed very early in a peacekeeping operation. Base camp sites are being selected and evaluated for follow-on forces as the mission expands. Planners have selected a location for a large base camp near a small city which has a municipal water supply. Logisticians want to use that municipal supply for the camp without treatment by Army ROWPU technology. The test strip from your WQAS-PM indicates the presence of cyanide at concentrations around 4 mg/L. The source of cyanide could be the deliberate use of hydrogen cyanide in the water as a chemical weapon, or the source could be one of several industries in the area.

Single Contaminant Evaluation:

1. You refer to the MWGs-S for cyanide in Appendix D. For a temperate climate location (5 L/day consumption), no adverse health effects are expected for daily consumption of 6 mg/L for up to two weeks. However, if the climate is arid, then some adverse health effects may be expected.

2. In the Compound column: You note that the values in the TG came from the Tri-Service Field Drinking Water Standards (TB MED 577).

3. Now you refer to the "Notes" column of Appendix D. The absence of a carcinogen statement indicates that the EPA does not consider cyanide to be a carcinogen.

4. You get more details by referring to the "Notes" column of Appendix D or to the Tri-Service Drinking Water Standards *(*TB MED 577). Concentrations between 12 mg/L and 24 mg/L at a 5 L/day consumption rate will result in detectable changes in blood chemistry but probably no clinical effects. Increasing concentrations starting at 24 mg/L at 5 L/day consumption will produce increasing frequency and severity of headaches, weakness, palpitation, nausea, giddiness and tremors. Concentrations greater than 48 mg/L are expected to produce life-threatening toxicity.

General Conclusions:

The presence of cyanide in the local municipal water supply indicates that the integrity of that source of drinking water for the planned base is compromised. Though you do not consider the severity to be critical, much less catastrophic, without continuous monitoring, there is no way to know if the cyanide levels will fluctuate over time or what the magnitude of the fluctuations would be.

At an average rate of consumption of 5 L/day, deployed military personnel drinking the municipal water should experience no adverse health effects for up to two weeks of consumption, assuming no other contamination and no increase in the cyanide concentration. At 15 L/day average consumption, deployed military personnel consuming the water may experience some adverse health effects, although the additional information in TB MED 577 indicates that the severity of symptoms and the number of personnel experiencing any symptoms would probably be minimal.

Your current assessment indicates results in a *marginal* to *possibly negligible degree of risk severity.* Given the potential variability, you estimate a *likely probability* that this degree of health risk will occur, resulting in a *low* to *moderate overall risk level*.

Given this potential level of risk, you determine that the source should be considered as viable so long as continuous or frequent monitoring of the water is performed to ensure levels are maintained (or diminished). This can be easily done with test strips. The other option is to consider a protected water supply, such as a new well drilled by the Corps of Engineers and dedicated to your planned base camp, with well water treated by appropriate technology, or obtain supplied bottled water. Note that cyanide cannot be removed from water by Army ROWPU technology. You provide this information to the commander who decides logistically it makes more sense to use the existing source. The commander requests that you monitor the situation regularly and update him with any changes in the assessment of the health risks.

SCENARIO 7: OPERATIONAL HAZARDS

*You are deployed on a peacekeeping mission as in Scenario 1. High-volume air sampling was performed and identified the following compounds at the concentrations show*n:

	Sample 1	Sample 2	Sample 3
Benzene	0.02 mg/m^3	0.008 mg/m^3	0.05 mg/m^3
Toluene	0.013 mg/m^3	0.016 mg/m^3	0.05 mg/m^3
Hexane	0.21 mg/m^3	0.032 mg/m^3	0.09 mg/m^3
Carbon tetrachloride	0.001 mg/m^3	0.005 mg/m^3	0.009 mg/m^3

Some of the compounds are typical components of fuel. You note that the high-volume sampler is located on a building near where a fueling point has been set up and that some personnel are housed in tents in this general area. The high volume sampling measures the ambient concentrations for personnel living in the general area. You decide to collect further air samples at the fueling point itself to evaluate the exposures of the individuals working at the fueling point. When you evaluate the operations, you notice that fuel is sometimes spilled while personnel are refueling and that containers are sometimes filled with fuel. You also notice that degreasing solvents are sometimes used in this area. The following results are obtained during the normal course of operations as described above:

	Sample 1	Sample 2	Sample 3
Benzene	2.0 mg/m^3	1.7 mg/m^3	1.3 mg/m^3
Toluene	42.0 mg/m^3	34.0 mg/m^3	4.0 mg/m^3
Hexane	31.0 mg/m^3	19.0 mg/m^3	6.0 mg/m^3
Carbon tetrachloride	5.0 mg/m^3	2.0 mg/m^3	0 mg/m^3

In this scenario, your evaluation confirms that the source is associated with the fueling operations. As you know that these operations are just like daily (8-hour day) industrial operations performed in garrison, you determine that you should evaluate the criteria with appropriate *occupational*

guidelines. In such a case, USACHPPM TG 230A guidelines are inappropriate (e.g., the 1-14 days are overly conservative as they accommodate for a 24-hour daily exposure). You do note the potential hazards of establishing living quarters in this area. You, therefore, recommend several easily accommodated management actions to include procedures to minimize spills, properly containerize fuels and wastes, and the relocation of a few tents.

APPENDIX F

WATER QUALITY INFORMATION PAPER NO. IP-31-014
WATER PURIFICATION BY REVERSE OSMOSIS

Authors:

W. DICKINSON BURROWS, PhD, P.E., DDE
Environmental Engineer
Water Supply Management Program, USACHPPM

JERRY A. VALCIK, P.E., DDE
Program Manager
Water Supply Management Program, USACHPPM

Water Quality Information Paper No. IP-31-014, Water Purification by Reverse Osmosis

1. PURPOSE. This information paper provides guidance on the performance of the reverse osmosis water purification unit (ROWPU) with respect to removal of soluble contaminants from source waters. It is intended for the use of all preventive medicine and water point personnel, whether or not they have received formal instruction in membrane technology.

2. DISCUSSION.

a. Principles.

(1) Osmosis, for our purpose, is the process whereby water passes through a *semipermeable* membrane, i.e., a membrane that obstructs the passage of salt or other material dissolved in the water. The direction of water passage is from the dilute solution side of the membrane to the concentrated side. For example, if a living cell is emersed in distilled water, the cell swells - sometimes to the bursting point - as water flows in through the cell membrane. If, on the other hand, the same cell is emersed in a saturated salt solution, water flows out and the cell is dehydrated, which is how road salt kills vegetation.

(2) Applying pressure to the concentrated solution side of a membrane reverses this osmotic process. This process allows us to construct a device to extract pure - or nearly pure - water from solutions of salt and other dissolved materials in a manner analogous to distillation, except that pressure provides the driving force rather than temperature. The ROWPU is such a device.

b. Removal of Simple Salts.

(1) It is important to understand that the original 600 gph ROWPU was designed to produce potable water from seawater or brackish water, i.e., to remove sea salts, principally sodium chloride or common salt. Other significant seawater constituents include salts of magnesium, calcium and potassium, as well as salts of bromine, sulfur (in the form of sulfate) and carbon (in the form of carbonate and bicarbonate). The product water from the ROWPU has 98-99 percent of the sodium chloride removed (*rejected*) and at least that much of the other sea salts. Ordinary seawater contains about 3.5 percent (35,000 ppm) sea salts, so the product water should contain 350-700 ppm dissolved salts. This is more salt than in most municipal drinking water, but it is still well within the Army field water standard (1,000 mg/L). Note that if the seawater contains more than 3.5 percent salts, as is the case in the Persian Gulf, the ROWPU

still removes just 98-99 percent. Thus, if the seawater contains 6 percent (60,000 ppm) salts, the product water will contain 600-1,200 ppm and may taste very slightly brackish. If, on the other hand, the ROWPU is used to purify fresh water, the product water may contain almost no salts and may taste *flat*.

(2) The membranes in the ROWPU are manufactured to remove sea salts. Any other chemical removal is a bonus, but such removal must be determined experimentally for the particular membrane, for each chemical, and for the conditions (temperature, pH, pressure) under which the equipment will be used. Some typical rejection data are presented in Table 1 for membranes similar to those used in the ROWPU. However, many new membranes, tailored for specific purposes, are being marketed. Some of these membranes may give significantly improved salt rejection and may provide greatly altered selectivity.

TABLE 1. REJECTION OF SALTS BY A TYPICAL RO MEMBRANE*

Salt	Rejection, percent
Sodium chloride	98
Magnesium chloride	98
Calcium chloride	99
Magnesium sulfate	99
Sodium bicarbonate	98
Sodium nitrate	93
Sodium fluoride**	98

* Filmtec , spiral wound, thin film composite polyamide. Data are provided by the manufacturer for pure solutions of each salt; they are not applicable to mixtures of salts.
**Fluoride rejection is pH dependent: about 75% at pH 5, 50% at pH 4, 30% at pH 3.5 and 0 % at pH <3.

Filmtec is a registered trademark of FilmTec Corporation, Minneapolis, MN.

c. Industrial Inorganic Chemicals.

(1) Most inorganic salts, including industrial chemicals, are removed from water by the ROWPU as well as sodium chloride. However, some inorganic salts are poorly removed (Table 2). Product water from a river contaminated with plating wastes will probably have 98-99 percent of nickel, copper and zinc removed and 96-98 percent of the cadmium, but perhaps only 90 percent or less of the chromium and cyanide. This may not seem like much of a difference, but note that a process which removes 90 percent of a pollutant leaves 10 times as much of the . pollutant in the product water as one that removes 99 percent. Removal efficiency is poor for mercury (33-78 percent) and arsenic (69-99 percent, depending on the chemical form). Removal efficiency is good for iron and manganese, but these metals may cause excessive fouling of the membranes.

TABLE 2. REJECTION OF HEAVY METAL SALTS BY TYPICAL RO MEMBRANES

Salt	Rejection, percent
Nickel sulfate	99
Copper sulfate	99
Arsenic (+5) salts	99
Arsenic (+3) salts	69 and lower
Cadmium salts	99
Lead salts	97
Mercury salts	33-78
Chromium (+6) salts	97
Chromium (+3) salts	96

(2) Many of the common heavy metals found in polluted waters (lead, mercury, cadmium, arsenic, and chromium in particular) are highly toxic, and while the ROWPU may remove them well enough to meet health standards, it is still important to select the best raw water source available. This places increasing importance on the role of preventive medicine personnel in the process of water point site selection.

d. Organic Chemicals.

(1) Removal of organic materials may depend on size (i.e., molecular weight), structure and substitution (Table 3). Natural organic materials in water (lignans, tannins, fulvic substances) are essentially all removed, as are carbohydrates, proteins, and amino acids. Rejection of

contaminants from industrial sources is highly variable. Removal efficiency is poor for low molecular weight alcohols such as methyl, ethyl, propyl and isopropyl alcohol, as well as for most low molecular weight solvents, including chlorinated solvents. In general, initial removal improves with increase in molecular weight, but this may be deceiving. Many organic contaminants that show good short-term removal in bench tests may *leak* through the membrane in days or even hours. For example, removal of lindane may fall from an initial 97 percent to 85 percent after 24 hours. Weak organic acids of low molecular weight (acetic acid and its simple derivatives, propionic acid, butyric acid, phenol) are poorly removed.

TABLE 3. REJECTION OF SOME ORGANIC CHEMICALS BY TYPICAL RO MEMBRANES

Chemical	Rejection, percent
Aldehydes and Alcohols	
Formaldehyde	35
Methanol	25
Ethanol	70
Isopropanol	90
Sucrose (cane sugar)	99
Acids	
Acetic acid	60-90
Fluoroacetic acid*	98-99
Phenol	56-87
Benzoic acid	87-92
Solvents	
Trihalomethanes	50-80
Chloroethylenes	15-90
BTEX	15-50
Chlorobenzene	40-50
Herbicides	
Atrazine	96
Alachlor	98
Linuron	98

* Rodenticide; extremely toxic to humans

(2) Most organics will not cause acute health problems at the concentrations found even in polluted source water, although they may impart a taste so unpleasant that consumers will risk dehydration rather than drink it. However, some may present the risk of long-term health problems such as cancer. Because of the uncertainty in efficiency of rejection of industrial organics, it is again important to select the least contaminated source water for treatment.

Surface waters immediately downstream from municipal or industrial outfalls should be avoided, in particular the outfall from a petrochemical complex

e. NBC Agents. Removing NBC agents from water by RO has received only limited investigation (Table 4). A single study indicates that the biotoxins, such as ricin, are reduced below detection limits by membranes similar to those in the ROWPU. Other studies indicate better than 99 percent removal for chemical agents and 95 percent or better removal for certain radioactive chemicals (nuclear agents). However, it is also known that radioactive materials eventually damage RO membranes. Furthermore, it may be assumed that membranes exposed to a constant challenge will eventually pass larger concentrations of chemical agents (but not most biotoxins).

TABLE 4. REJECTION OF NBC AGENTS BY REVERSE OSMOSIS

Agent	Rejection, percent
T-2	100
Microcystin	100
Ricin	100
Saxitoxin	100
GB	>99
VX	>99
BZ	>99
Hydrogen cyanide	<25*
^{131}I	>95
^{85}Sr	>99
^{134}Cs	>98

*pH $\leq$ 8.5

f. Parasites, Bacteria and Viruses. Reverse osmosis membranes have not, for the most part, been specifically tested for removal of bacteria, viruses, and parasites, such as *Giardia* or *Cryptosporidium* cysts. Based on size exclusion, it may safely be assumed that an undamaged membrane will remove virtually 100 percent of all microbiological organisms (although recent studies have indicated that virus removal efficacy may be subject to quality control limitations in membrane manufacture). Thus, the ROWPU is an effective barrier to water-borne pathogens.

However, it is still important to avoid source water that may contain human or other animal wastes and to disinfect the ROWPU product water in order to prevent possible bacterial recontamination.

3. CONCLUSIONS. The ROWPU is a highly effective device for removing water pollutants and can provide an ample supply of assured safe drinking water if reasonable care is exercised in selection of the raw water source. It must be emphasized that the tabular data presented in this technical guide are for illustrative purposes only, and should not be used to estimate ROWPU product water quality except in the most general sense. Reverse osmosis performance depends, among other things, on the operating parameters, the choice and condition of the membrane, and the pH and temperature of the water. Knowledge of performance of the ROWPU with respect to individual source water constituents is still limited.

4. ADDITIONAL INFORMATION. Field preventive medicine personnel and others with specific health-related questions on treatment of water for both potable and nonpotable use are urged to contact the Water Supply Management Program, U.S. Army Center for Health Promotion and Preventive Medicine: phone (410) 436-3919, DSN 584-3919; Fax (410) 436-8104; email: wsmp@apgea.army.mil; home page: http://chppm-www.apgea.mil/dwater.