

HAZARD EVALUATION HANDBOOK

A Guide to Removal Actions

**Prepared by
the Roy F. Weston
Technical Assistance Team
for the
U.S. Environmental Protection Agency
Region III, Superfund Removal Branch
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US EPA Region 3
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Introduction

This book is the second edition of a guidebook for U.S. EPA project managers, inspectors, and others to help them view a project site from a multimedia perspective and to recognize potential emergency or removal conditions that may not be obvious. It is essential that the project manager or inspector question everything at a project site in terms of the imminent threat posed to human health and the environment. Such questioning at times involves thinking like a detective in order to uncover hidden, yet serious threats. The fictional character Sherlock Holmes was a masterful detective, and an exploration of the differences between Holmes and his less agile associate, Dr. Watson, may be instructive.

The obvious advantage that Sherlock Holmes has over Dr. Watson is that Holmes is the consummate logician. But Holmes's superior use of deductive reasoning is not the only difference between the two characters. There is another, more subtle, perhaps more compelling difference. Holmes has the superior imagination. He looks at a set of clues, sees a wealth of related possibilities, then logically deduces the most reasonable possibility on the basis of the evidence at hand. Watson can see only the clues; he cannot imagine them as part of any possible encompassing whole.

This ability to look at a clue and to imagine a host of possible ramifications--to ask "what if?"--is just as important to EPA project managers as they explore a new site as it is to Holmes as he explores a new case. One reason this ability is valuable to project managers is that it allows them to assess risk more fully and to determine more accurately whether there is potential for a removal action.

According to the National Contingency Plan, 40 CFR Part 300.420 (b) and (c), among the goals of a Remedial preliminary assessment and of a site investigation are to determine if there is any potential need for Removal action, and, if the assessment or investigation indicates that a Removal action is warranted, to initiate a Removal site evaluation pursuant to 40 CFR Part 300.410. Removal actions are warranted in unstable or potentially unstable situations that pose immediate threats to public health and the environment. Examples of such threats are weathered, leaking drums; potentially explosive substances; damaged buildings or other structures with a high potential for causing hazardous substances to be released from containment; and so forth. The purpose of this book is to help Remedial Project Managers understand the processes involved in a Removal site evaluation and recognize the potential sources of immediate hazards at various types of sites. Such recognition is important not only to fulfill the mandates of the NCP, but also to maintain maximum site safety and security during remedial actions.

Many sites, such as those being evaluated for the National Priorities List (NPL), are examined by the Pre-Remedial Program first, not the Removal Program, so it is important that these sites be examined in light of their potential for causing imminent threats. Other sites undergo emergency removal actions by the Removal Branch first and then are transferred to other programs for additional action. During the subsequent transition period, conditions that were stable at the end of the Removal response may have deteriorated so that an imminent threat is posed to the public or to the environment. Remedial sites are of concern because the remedial process can take years, during which weathering and wearing of storage and containment facilities can occur. The NPL Site Certification process requires the periodic evaluation of Remedial sites. These evaluations should include an assessment of the need for a Removal action.

This book is meant only as a guide to the possible sources of harm presented by various types of sites; it is not an exhaustive study. Instead, the purpose of the book is to encourage project managers and others to examine a site from several different perspectives in evaluating potential hazards. Holmes had Dr. Watson with him to ask "who," "what," "when," "where," "why," and "how." But each person onsite must ask these questions for himself or herself.

Acknowledgments

This book was prepared by the Roy F. Weston Technical Assistance Team (TAT) under the coordination of Gregg Crystall, Chief, Eastern Response Section, Superfund Removal Branch, U.S. EPA Region III. Dr. Roy L. Smith, U.S. EPA toxicologist in Region III, made a major contribution to the project by collecting dosage data and calculating the reference dose concentrations in Chapter 4, Emergency Removal Guidelines. Many TAT members made direct and indirect contributions to this project. The project could not have been successfully completed without the assistance of the EPA and TAT personnel involved.

Safety

Certain safety precautions should be considered before entering an area of any description that is suspected to be contaminated with hazardous substances. These precautions are necessary to prevent short-term exposure and injury and the long-term effects of multiple short-term exposures.

- **Review background information about the facility prior to making a site visit. A background search may provide such useful information as the names of any process chemicals used at the facility, contact names, and site-specific hazards and may assist field personnel conducting the assessment.**
- **Draft a site health and safety plan to address all chemical, physical, biological, and radioactive hazards associated with the site. Modifications to the safety plan can be made as additional information is collected.**
- **Conduct an initial survey of the site from a safe distance away to determine if there are any visible hazards that should be addressed or avoided when entering the site. If the contaminants are known, it is possible to gather information from the numerous reference sources available, prior to going on the site.**

- **When making an entry into a site where the materials are unknown, high levels of protection (Level B or higher) are recommended until sufficient data has been collected to determine that lower levels of protection are sufficient. During the assessment, the entry team will use direct air monitoring equipment to check for radiation, combustible gases, and volatile organic and inorganic vapors. Multimedia (air, water, and soil) samples should also be collected to determine actual concentrations of the contaminants onsite.**
- **Based on the initial survey, select the proper type of personal protective equipment to safely perform tasks required for further site assessment. Personal protection may include a self-contained breathing apparatus (SCBA) or air-purifying respirator (APR), chemical protective coveralls, chemical-resistant gloves and boots, a hard hat, and safety goggles. The purpose of the protective equipment is to minimize the risk of exposure to hazardous substances through inhalation, ingestion, or skin contact.**
- **Personnel working onsite must have completed a minimum level of OSHA-required training.**
- **Ensure that all persons entering the site read and understand the site health and safety plan in order to limit the number of injuries.**

Sources of Information

Questions about the hazards posed by a site and whether a Removal response is appropriate can be answered by the EPA Region III Removal Branch. Call the following people for information:

Gregg Crystall, Section Chief - (215) 597-9893
Eastern Response Section (3HW31)
Superfund Removal Branch

Charles Kleeman, Section Chief - (215) 597-4018
Western Response Section (3HW32)
Superfund Removal Branch

Karen Wolper, Section Chief - (215) 597-8751
Enforcement Section (3HW33)
Superfund Removal Branch

David Wright, Section Chief - (215) 597-5998
Oil and Title III Section (3HW34)
Superfund Removal Branch

Regional Response Center - (215) 597-9898

An On-Scene Coordinator from the Superfund Removal Branch is on duty outside of normal working hours and can be reached through the Regional Response Center to answer questions.

Questions about the degree of toxicity posed by a substance and its possible effects should be referred to the EPA Region III Technical Support Section (3HW15). Call the following people for information:

Eric Johnson, Section Chief - (215) 597-8907

Richard Brunker, Toxicologist - (215) 597-0804

Nancy Cichowicz, Geologist - (215) 597-8118

Kathryn Davies, Hydrologist - (215) 597-6488

Robert Davis, Biologist - (215) 597-3155

Debra Forman, Toxicologist - (215) 597-6626

Reginald Harris, Environmental Scientist - (215) 597-1309

Dawn Ioven, Toxicologist - (215) 597-1309

David Kargbo, Geologist - (215) 597-8118

Paul Mlodzinski, Co-op - (215) 597-8185

Edward Newbaker, Environmental Scientist - (215) 597-1268

Bernice Pasquini, Environmental Scientist - (215) 597-2365

Nancy Rios, Environmental Scientist - (215) 597-6682

Philip Rotstein, Hydrologist - (215) 597-6626

Bruce Rundell, Environmental Scientist - (215) 597-1268

Roy L. Smith, Toxicologist - (215) 597-6682

Mindi Snoparsky, Geologist - (215) 597-2365

Toxicological information may also be obtained from:

Samuel Rotenberg, Toxicologist - (215) 597-2842

Integrated Management and Support Section (3HW53)

Kathleen Shelton, Environmental Scientist - (215) 597-9287

Corrective Action RCRA Enforcement Section (3HW61)

Additional information can be obtained from:

**American Association Of Railroads - (202) 639-2100,
(202) 629-2222**

The association provides assistance at sites involving rail shipments of hazardous materials.

**Center for Disease Control - (404) 633-5313
(24 hours)**

The CDC provides assistance in emergencies involving bacterial agents or infectious diseases.

Chemical Emergency Preparedness Program - (800) 535-0202

This hotline provides information on reporting of hazardous substances for community planning purposes.

CHEMTREC - (800) 424-9300 (24 hours)

CHEMTREC provides information concerning materials involved in hazardous materials incidents. CHEMTREC can also contact manufacturers, shippers, or other parties who may be able to provide additional assistance. A supplement to CHEMTREC is the HIT (Hazard Information Transmission) program, which provides a hard copy of hazard data. Non-emergency service can be obtained from CHEMTREC by calling (800) 262-8200, between 8 a.m. and 9 p.m. EST. CHEMTREC is operated by the Chemical Manufacturers Association.

**National Animal Poison Control Center - (217) 333-3611
(24 hours)**

The center is operated by the University of Illinois and provides assistance at sites involving suspected animal poisonings or chemical contamination.

**National Pesticide Telecommunications Network -
(800) 858-7378**

The network provides information about spill handling, disposal clean-up, and health effects of pesticides.

Safe Drinking Water - (800) 426-4791

This hotline provides information about the public water supply program, policy, and technical and regulatory items.

Solid Waste and Hazardous Waste (RCRA) and Superfund - (800) 424-9346

This hotline provides information about the Resource Conservation and Recovery Act and Superfund. It is operated by EPA.

Texas Tech University Pesticide Hotline - (800) 858-7378

The hotlines provides emergency information in pesticide-related incidents.

TSCA and Asbestos Technical Information and Referral - (202) 554-1404

This hotline provides information on the Toxic Substances Control Act and on asbestos.

US Department of Transportation Hotline - (202) 426-2075

The hotline provides information and assistance concerning the hazardous materials regulations found in the Code of Federal Regulations Title 49.

Computer Resources**TOXNET**

TOXNET, managed by the National Library of Medicine, provides access to data bases on toxicology and related issues. Five integrated data base modules are accessible: the Hazardous Substances Data Bank (HSDB), Registry of Toxic Effects of Chemical Substances (RTECS), Chemical Carcinogenesis Research Information System (CCRIS), Directory of Biotechnology Information Resources (DBIR), and Environmental Teratology Information Center Backfile (ETICBACK). Call (301) 496-6531 for account information.

CHEMICAL INFORMATION SYSTEMS INC

CIS provides access to about nine different data bases. Among the data bases are the Oil and Hazardous Material/Technical Assistance Data System (OHMTADS), the Chemical Hazard Response Info System (CHRIS), and the MERCK index. CIS also provides access to the SPHERE family of components sponsored by the Office of Toxic Substances of U.S. EPA, including DERMAL, ENVIROFATE, and ISHOW. Call (800) CIS-USER for account information.

CAMEO

The Computer-Aided Management of Emergency Operation (CAMEO) program provides response information and recommendations for over 2500 commonly transported chemicals, an air dispersion model, and components for emergency response planning. Call (206) 526-6317 for account information.

Conducting a Removal Assessment

Certain safety precautions should be considered before entering an area of any description that is suspected to be contaminated with hazardous substances. The National Contingency Plan, 40 CFR Section 300.410, gives the minimal procedures for conducting a removal site evaluation, which "includes a removal preliminary assessment and, if warranted, a removal site inspection." According to the NCP:

300.410(c)(1) The lead agency shall, as appropriate, base the removal preliminary assessment on readily available information. A removal preliminary assessment may include, but is not limited to:

- (i) Identification of the source and nature of the release or threat of release;**

This may be as easy as reading the U.S. Department of Transportation (DOT) placard on a tank truck. In the case of a hazardous waste site with hundreds of possibly unlabeled drums of different chemicals, recognition of the source and nature of the threat posed requires use of all information available; e.g., historical data, visual observation, monitoring data, sample data, package labels, shipping manifests, and witnesses.

- (ii) **Evaluation by ATSDR or by other sources, for example, state public health agencies, of the threat to public health;**

In order to evaluate the level of threat that a site poses to public health, ATSDR (Agency for Toxic Substances and Disease Registry) requires a report that describes the site and its history; lists the substances present onsite and the quantity of contaminated material in different media (soil, water, air); describes the relationship between the site and such environmental pathways as ground water, surface water, soil, sediment, and air; and provides documentation of quality control/quality assurance for supporting sample data. Similar reports can be prepared for EPA toxicologists and other public health officials so they can evaluate the degree of threat posed by a site.

- (iii) **Evaluation of the magnitude of the threat;**

Evaluation is determining the actual or potential impact of a threat to public health and welfare and to the environment. To evaluate the magnitude of a hazardous materials site, all substances must be identified, their concentrations determined, and their dispersion pathways established. Then, risk can be assessed on the basis of exposure or the threat of exposure to the public and the environment.

- (iv) **Evaluation of factors necessary to make the determination of whether a removal is necessary; and**

The eight criteria for a removal are set forth in Section 300.415 of the NCP. These criteria are qualitative in nature, and it is not necessary that all of them be satisfied for a removal to be initiated. The criteria are discussed below.

- (v) **Determination of whether a nonfederal party is undertaking proper response.**

Research whether state and/or local agencies or the potentially responsible party (PRP) have taken action to mitigate conditions at the site.

300.410(c)(2) A removal preliminary assessment of releases from hazardous waste management facilities may include collection or review of data such as site management practices, information from generators, photographs, literature searches, and personal interviews conducted, as appropriate.

300.410(d) A removal site inspection may be performed if more information is needed. Such inspection may include a perimeter (i.e., offsite) or onsite inspection, taking into consideration whether such inspection can be performed safely.

Initial entry personnel should determine the presence of any hazards that may affect response personnel, the public, and the environment; verify existing information and obtain additional information about the site; evaluate the need for prompt action to mitigate any situation onsite; and collect information to establish safety requirements for additional personnel entering the site.

NCP Criteria For Initiating A Removal Action

Section 300.415 of the NCP sets forth the criteria for determining whether a removal action is warranted. If the site meets one or more of the criteria, a Removal action may be necessary.

300.415(b)(2) The following factors shall be considered in determining the appropriateness of a removal action pursuant to this section:

- (i) Actual or potential exposure to nearby human populations, animals, or the food chain from hazardous substances or pollutants or contaminants;**

Determine whether the site poses a direct exposure threat. Look for evidence of children playing in or near the site. Look for evidence of people walking or riding through the area, possibly stirring up contaminated dust. Check for schools, retirement communities, hospitals or other institutions nearby with sensitive populations that may be affected by site emissions. Explore

whether contaminated runoff from the site enters nearby streams or impoundments. Look for wells in the vicinity of the site that are affected by ground water contaminants. Determine whether the contaminants are likely to enter the food chain through biouptake.

(ii) Actual or potential contamination of drinking water supplies or sensitive ecosystems;

Determine whether the release affects or has the potential to affect a ground water aquifer or surface waterway used for drinking water. Check for any fragile natural areas (e.g., the habitat of an endangered species) that may be affected by contaminants from the site.

(iii) Hazardous substances or pollutants or contaminants in drums, barrels, tanks, or other bulk storage containers, that may pose a threat of release;

Determine how structurally secure containers are. Look for any signs of weathering or structural instability. Based on the condition of any containers and the quantity of material present, determine whether an uncontrolled release is an imminent threat.

(iv) High levels of hazardous substances or pollutants or contaminants in soils largely at or near the surface, that may migrate;

Look for visible discoloration of the soil and for standing pools of discolored liquid. Look for any dead or dying vegetation; it may imply the presence of soil contamination that is not visible. Determine where runoff goes.

(v) Weather conditions that may cause hazardous substances or pollutants or contaminants to migrate or be released;

Determine whether precipitation can initiate a release (e.g., a lagoon overflow) or cause contaminants already released to migrate. Check for any containers that are exposed to the weather, which facilitates structural deterioration.

- (vi) **Threat of fire or explosion;**
Check for any flammable/explosive substances that may be present, including any initially stable substances that may have deteriorated to the point of being explosively unstable. Check for the presence of strong oxidizers. Determine whether any incompatible substances are stored together. Examine the history of the site for incidences of accidental fire, explosion, or arson.
- (vii) **The availability of other appropriate federal or state response mechanisms to respond to the release;**
Ascertain whether other federal or state agencies are prepared to provide resources to mitigate the release or threat of release.
- (viii) **Other situations or factors that may pose threats to public health or welfare or the environment.**
Be alert for any other condition, in addition to the ones specifically given in the NCP criteria, that may pose an imminent threat.

Conducting a Removal Preliminary Assessment and Site Inspection

PRELIMINARY ASSESSMENT

Before site entry, the investigation team should gather and review information about site activities and the chemicals used and/or generated so that hazards can be evaluated to the extent possible and preliminary controls established to protect initial entry personnel. This preliminary evaluation should provide the following information:

- The location and approximate size of the site.
- The site history, especially waste disposal history.
- A description of the topography of the site, the number and types of structures present, and routes of accessibility. Natural wind barriers such as buildings, hills, and storage tanks should also be identified, as well as how land surrounding the site is used.

- Descriptions of the hazardous substances known or suspected to be onsite and their chemical and physical properties and associated risks.
- An estimation of the types of changes that may have occurred onsite as the result of aging, weathering, fire/explosion, and so forth. Changes include structural damage to buildings and containers, as well as chemical alteration of hazardous substances present. Any such changes may increase the risk to personnel entering the site.
- Pathways for dispersion of hazardous substances from the site. Potential pathways include the air, such biologic routes as the food chain, ground water, surface water, and direct contact. Adjacent properties and the sensitivity of the surrounding environment should be considered.
- A description of the response activities or other tasks to be performed onsite and an estimate of their duration.

Information can be obtained through a search of state and federal regulatory and enforcement records (including previously gathered U.S. EPA Removal and Remedial data and information from other EPA programs such as the National Pollutant Discharge System for water), local government records, the potential responsible party's records (logbooks, shipping manifests, ledgers, etc.), interviews with adjacent property owners and previous site workers, and perimeter reconnaissance. If the preliminary offsite evaluation does not produce sufficient information to identify and quantify the suspected hazards, an initial site entry and characterization are performed.

SITE INVESTIGATION

During the site investigation, entry personnel should monitor the air for conditions that are immediately dangerous to life and health (IDLH) or that may cause serious harm. Such conditions include combustible or explosive atmospheres, oxygen deficiency, and the presence of airborne toxic substances that pose a high threat through skin absorption and/or inhalation. To supplement air monitoring, personnel should look onsite for indicators of IDLH conditions. Indicators include dead animals; stressed vegetation; and bulging,

fuming, hissing, or otherwise stressed containers. Be alert for the presence of something onsite that may imply the presence of a hidden hazard; for example, the edge of one rusty drum protruding through a tangle of vines could indicate that the vines are covering a pile of drums. Personnel should also monitor for ionizing radiation and note any slip-trip-fall hazards. Once the hazards onsite have been evaluated and the initial safety plan revised accordingly, periodic monitoring should occur to ensure the safety of site workers during the remainder of the investigation.

It is critical that the hazardous materials onsite be identified exactly to assure safe and effective field operations. Several basic clues to their identity include:

- **Container shape and size.** Distinctive container shapes are used for certain types of substances, so basic clues to the identity of a hazardous material can be gathered from the container in which it is stored. Refer to Appendix 4 for silhouettes of some containers used in the transportation, storage, and use of hazardous materials.
- **Markings, placards, and labels.** Markings, placards, and labels, along with container shape and size, are the safest and easiest methods for determining the presence of hazardous materials. The DOT requires placards on containers used to transport 1000 pounds or more of most hazardous substances across state lines; the DOT requires placards for any amount of some particularly hazardous substances. The DOT Code of Federal Regulation, 49 CFR, gives the requirements for labeling and placarding hazardous materials within the United States. There is also a marking system administered by the National Fire Protection Association (NFPA) for fixed facility storage tanks. Refer to Appendix 5 for additional information on U.S. DOT and NFPA placards and labels.

NOTE: Remember that containers may be unlabeled or even mislabeled, either intentionally or through error. Exercise extreme caution until the presence or absence of a hazardous substance has been confirmed.

- **Senses.** The senses of sight, hearing, and smell can aid in the identification of hazardous materials. Sight and hearing are the safest senses to employ and are very valuable resources in determining the presence of hazardous materials. The sense of smell is potentially dangerous. Some materials are toxic at concentrations too low to be detected by smell, and other materials induce olfactory fatigue, so workers cannot distinguish increased concentrations. Generally, standard operating procedures state that if a worker is close enough to smell a substance, the worker is too close.

Qualitative Hazard Recognition

Qualitative hazard recognition, the realization that a hazard actually exists onsite, is the most crucial part of a removal site investigation. This section contains a general checklist of questions, pertinent to every site, to provide guidance in qualitative hazard recognition. Following the general checklist is a series of drawings of specific conditions that may not occur at every site. When they do occur, these conditions require a thorough evaluation, so a detailed checklist follows each drawing. This section concludes with a modified map of an actual site. A checklist follows the site map.

Use of the general checklist should give each project manager or inspector an idea of whether a removal may be warranted and provide background information about the site. The checklists associated with the drawings should be used in making a more detailed assessment of specific hazards.

The purpose of each checklist is to direct the thinking of site investigators; the checklists are guides, not all encompassing field lists that address every condition that may be encountered.

General Hazard Recognition Checklist for Each Site

- Key Points and Potential Hazards -

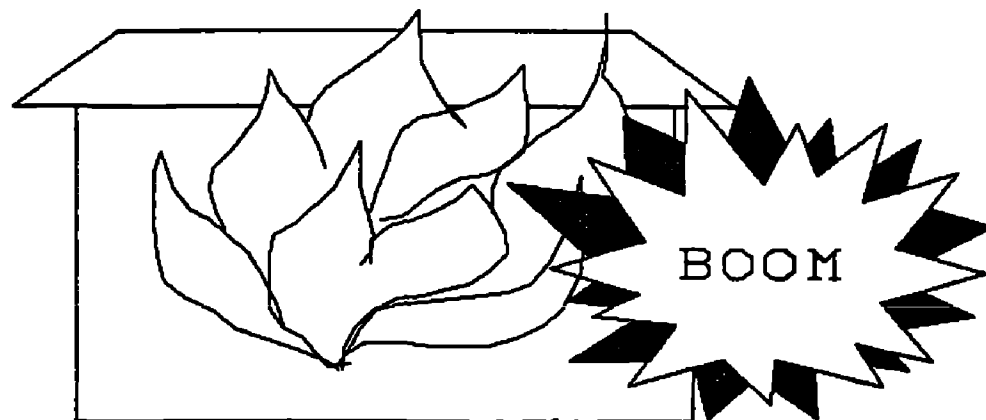
- 1. Note any indicators of potential exposure to hazardous substances:**
 - Dead fish, animals or vegetation.
 - Dust or spray in the air.
 - Fissures or cracks in solid surfaces that expose deep waste layers.
 - Pools of liquid.
 - Foams or oils on liquid surfaces.
 - Gas generation or effervescence.
 - Deteriorating containers.
 - Cleared land areas or possible landfilled areas. See detailed checklist on page 34.
 - Anything that appears unusual, out of the ordinary, for whatever reason.
- 2. Note the types of containers, impoundments, or other storage systems:**
 - Paper or wooden packages.
 - Metal (stainless steel, lead, etc.) or plastic barrels or drums; concrete storage containers. The composition of the container can be a clue to the contents.
 - Underground tanks.
 - Aboveground tanks.
 - Compressed gas cylinders.
 - Pits, ponds, or lagoons.
 - Other.
 - See detailed checklist on page 28, page 31, and page 37.
- 3. Note the condition of waste containers and storage systems:**
 - Structural soundness.
 - Visibly rusted or corroded.
 - Leaking or bulging.
 - Types and quantities of materials in container(s).

-
- Container labels indicating corrosive, explosive, flammable, radioactive, toxic, or biologically pathogenic material.
 - Presence or absence of secondary containment, such as a berm.
4. **Note the physical condition of materials onsite:**
 - Physical state: gas, liquid, or solid.
 - Color and turbidity.
 - Behavior, e.g., corroding, foaming, or vaporizing.
 - Conditions conducive to splash or contact.
 5. **Identify features of the land and natural wind barriers:**
 - Buildings, large aboveground storage tanks.
 - Hills.
 - Rows of trees.
 6. **Determine the potential pathways of dispersion:**
 - Air.
 - Surface water.
 - Ground water.
 - Land surface (direct contact).
 - Biologic routes such as plants and animals affecting the food chain.
 7. **Note any safety hazards. Consider:**
 - Condition of site structures.
 - Obstacles to entry and exit.
 - Homogeneity of the terrain.
 - Stability of the terrain.
 - Stability of stacked material.
 8. **Identify any reactive, incompatible, flammable, or highly corrosive wastes. How are they stored?**
 9. **Note the presence of any naturally occurring potential skin irritants or dermatitis-inducing agents or of any potentially hazardous animals. For example:**
 - Poison ivy, poison oak, and/or poison sumac.

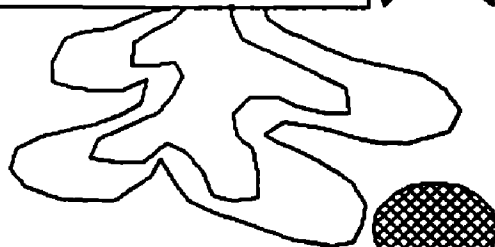
- Poisonous snakes.
 - Stray dogs.
- 10. Note any tags, labels, markings, or other identifying indicators.**
- 11. If warranted, use one or more of the following investigative techniques to locate buried wastes or contaminant plumes:**
- Electromagnetic resistivity.
 - Seismic refraction.
 - Magnetometry.
 - Metal detection.
 - Ground-penetrating radar.
- 12. Collect samples from:**
- Air.
 - Drainage ditches.
 - Soil (surface and subsurface).
 - Standing pools of liquids.
 - Storage containers.
 - Streams and ponds (upgradient, at suspected source, and downgradient).
 - Ground water (upgradient, beneath site, downgradient).
- 13. Sample for or otherwise identify:**
- Biologic or pathologic hazards.
 - Radiologic hazards.

HAZARD RECOGNITION - Fire/Explosion Scene

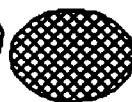
1. Damaged Structure



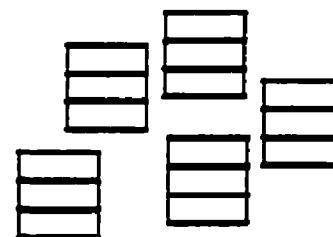
2. Contaminated Runoff



5. Drains



4. Bulk Storage



3. Drum Storage

Fire/Explosion Scene Checklist

- Key Points and Potential Hazards, -

1. Damaged Structure

- Unstable structures may pose physical hazards.
- Debris increases the risk of slip, trip, fall hazards.
- Fire often causes friable asbestos to become airborne.
- Smoke from even simple structure fires may contain many toxic chemicals.

2. Contaminated Runoff

- Runoff of water used to treat a fire will often be contaminated with chemicals released during the incident.
- The water may cause adverse reactions with reactive or unstable chemicals.
- The water may also be contaminated with combustion byproducts of chemicals stored or used at the facility.

3. Drum Storage

- Determine whether the drums have been impacted by either the fire, water, or chemical foam.
- Do the drums seem stable or stressed by heat or pressure?
- Can any special hazards be noted from visible label information?
- Note any physical damage caused by heavy equipment.
- Research the toxicity and physical properties of chemicals expected to be present.

4. Bulk Storage

- Determine whether the containers have been affected by either the fire, water, or chemical foam.
- Do the containers seem stable or stressed by heat or pressure?
- Are the pressure relief systems intact and actively venting?
- Are primary and secondary containment structures available and stable?
- Research the toxic and physical properties of chemicals expected to be present.

5. Drains

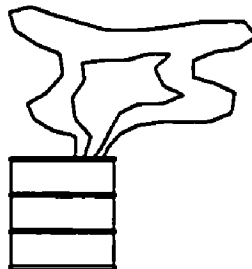
- Look for storm, sanitary sewer, and process water drains in the area.
- Are drain outfalls directed to a stream, river, or other sensitive area?
- Are drains connected to sump pits or other potential containment areas?
- Can drains be utilized for containment or blocked for protection if necessary?

HAZARD RECOGNITION - Drum Site

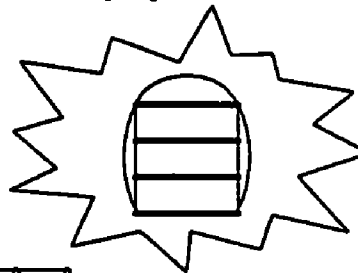
1 Unknown Drum



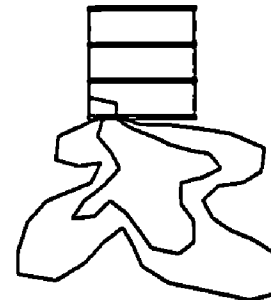
2 Vapor Release



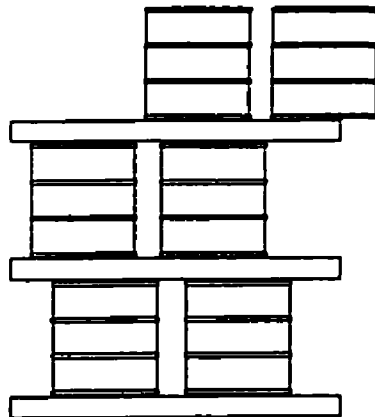
3 Bulging Drum



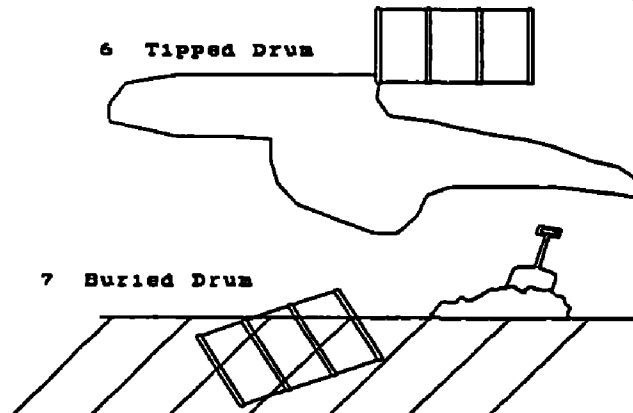
4 Leaking Drum



5 Drum Tiers



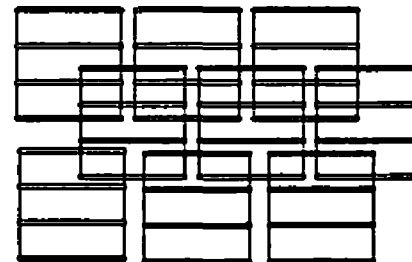
6 Tipped Drum



7 Buried Drum



8 Packed Drums



Drum Site Checklist

- Key Points and Potential Hazards -

1. Unknown Drums

- Do not make assumptions regarding the safety of drum contents until positive identification can be made; labels may not reflect the actual drum contents.
- Shaking drums to determine whether empty or not can initiate adverse reaction.
- Seemingly empty drums can still contain toxic residues.
- Determine materials drums are made of; e.g., fiber, stainless steel, aluminum, poly, lead. These materials may give clues to the nature of the contents and the associated hazards.
- Drums containing incompatible substances may be found together. If the drums are leaking, they may pose a fire/explosion threat.

2. Vapor Release

- Not all vapors are visible. Look near bung holes for air movement similar to heat waves.
- Respiratory protection is critical to cover inhalation and ingestion exposure routes.
- Determine if vapors can be confined and concentrated due to the nature of the surrounding area or structures.

3. Bulging Drum

- Determine if bulging is caused by pressure build-up or thermal expansion/ contraction.
- Bulging drums should never be opened by hand. A remote drum punch can open the drum and relieve the pressure.

4. Leaking Drum

- Contain leakage in place or block off any drains.
- Use pH paper to determine if the leaking material is corrosive.
- Any visibly stressed vegetation may indicate toxicity.

- If a smoking, fuming, or bubbling reaction is evident, it may indicate reactivity.

5. Drum Tiers

- Uneven stacking or corroded pallets/drums can present a physical hazard.
- Leaking drums on an upper tier can present a chemical hazard above the worker's head.
- Wooden pallets do not constitute a chemical barrier to prevent leaks from mixing and can pose a fire hazard in the presence of oxidizers.

6. Tipped Drum

- If a tipped drum is leaking from the bung, setting the drum upright or rolling so bung is upright can eliminate the problem.
- A leak underneath the drum may not be visible; look for clues such as discolored soil and stressed vegetation.

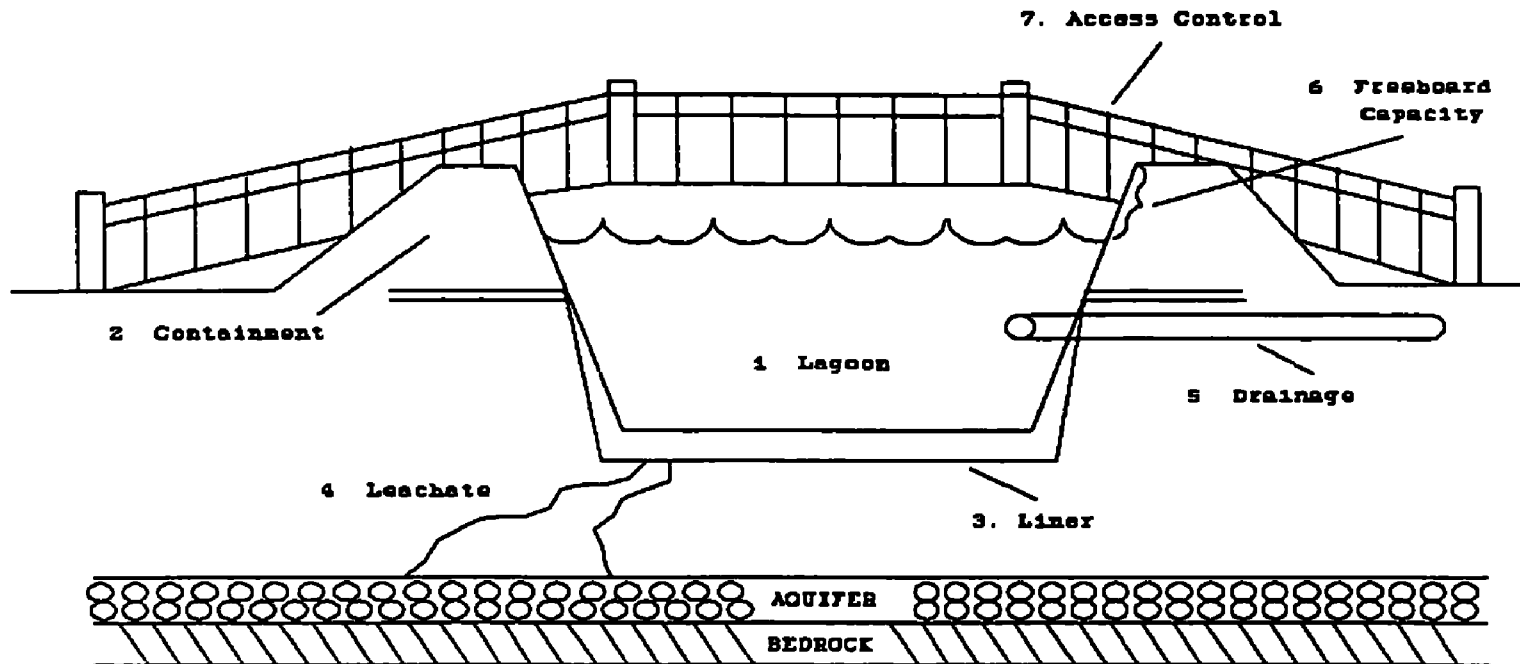
7. Buried Drums

- An uneven or disturbed soil surface may indicate buried objects.
- Drum heads often rise and break through the soil surface after burial.
- Caution should be exercised when using heavy equipment in areas that have or are suspected to have buried drums.
- An excavated drum may not be structurally sound due to container deterioration.
- Data obtained from soil gas testing, magnetometer surveys, and x-ray fluorescence may indicate the presence of buried drums.

8. Packed Drums

- Do not assume that inner drums in a tightly packed area of drums contain the same chemical as the accessible drums, or that the contents are compatible.
- Large amounts of chemicals can pool beneath and between the packed drums.
- It can be extremely difficult to identify and handle, or even to reach, a leaking or fuming drum within the pack.

HAZARD RECOGNITION - Lagoon



Lagoon Checklist

- Key Points and Potential Hazards -

1. Lagoon

- Document whether the lagoon is permitted or unpermitted.
- Determine the toxic and physical properties of the chemicals present in the lagoon.
- Note any stained soil or dead/dying vegetation in the area of the lagoon.
- Monitor for any air emissions in the vicinity of the lagoon.
- Characterize all layers of the lagoon - both liquid and solid layers.
- Check records for previous monitoring analysis of the lagoon contents.
- Research the hydrogeology of the area and the location of the water table with respect to the lagoon.

2. Containment Structure

- Note the stability of the berm construction.
- Document whether secondary containment is available in the event of failure.
- Document any seepage through the berm.
- Check whether the containment structure is adequately engineered to withstand normal stresses and strains.

3. Liner

- Check for a lagoon liner.
- Determine whether the construction materials of the liner are compatible with the contents of the lagoon.
- If possible, determine whether the liner was installed by professionals.

4. Leachate

- Determine what types of chemicals can be expected to leach from the lagoon. Determine whether direct contact is a threat with any surface leachate seeps.

- Determine whether surface seeps affect any surface waters, and whether a leachate pathway to a local aquifer is available.

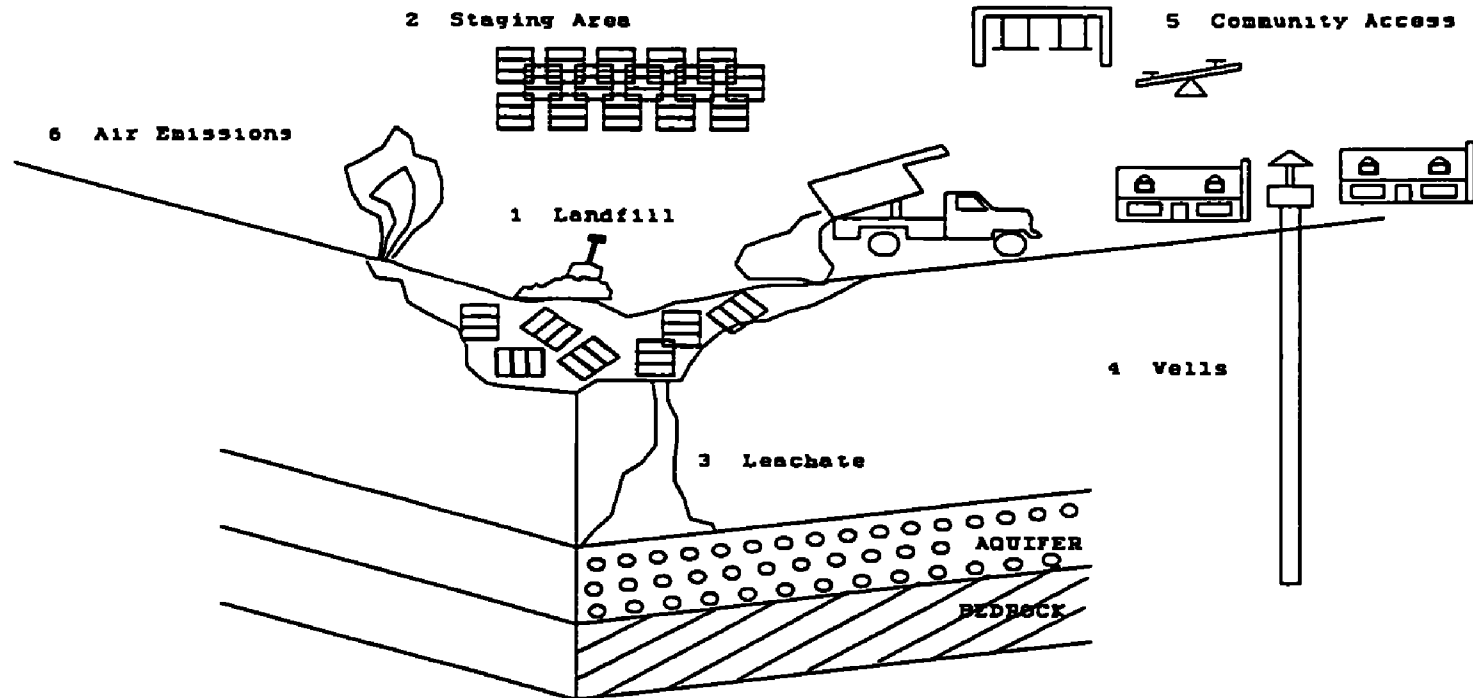
5. Drainage

- Identify all sources of drainage into the lagoon.
- Identify all sources of drainage out of the lagoon.
- Determine whether the lagoon liquid level rises or falls at unexpected times.
- Determine whether sufficient freeboard is available to prevent overflow of the lagoon under heavy precipitation.

6. Access Control

- Access should be restricted by a fence or other barrier.
- Look for any evidence of trespassers around the lagoon.
- Look for evidence of children playing in the vicinity of the lagoon.

HAZARD RECOGNITION - Landfill



Landfill Checklist

- Key Points and Potential Hazards -

1. Landfill

- Document whether the landfill is permitted or unpermitted.
- If permitted, document materials that are allowed.
- Document the history of disposal practices.
- Determine whether the landfill is lined or unlined.
- Look for evidence of illegal dumping or of dumping that is inconsistent with accepted practices.
- Research the hydrogeology of the area and the location of the water table with respect to the landfill.
- Research the toxic and physical properties of the chemicals present.

2. Staging Area

- Check for the presence of hazardous materials that are staged for disposal.
- Look for such surface contamination as stained soil or dead/dying vegetation in the staging area.
- Document whether access to the staging area is restricted by fencing or other barriers.

3. Leachate

- Determine the types of chemicals that can be expected to leach out of the landfill.
- Identify any pathways for leachate to local aquifers.
- Determine whether any surface leachate seeps pose a direct contact threat.
- Look for surface seeps that may affect surface waters.

4. Wells

- Document any monitoring wells in the area.
- Note any drinking water wells in the area.
- Research any sample information (both past and present) that may be available for nearby wells.

- Determine whether the state has more or less stringent water quality criteria than does EPA.

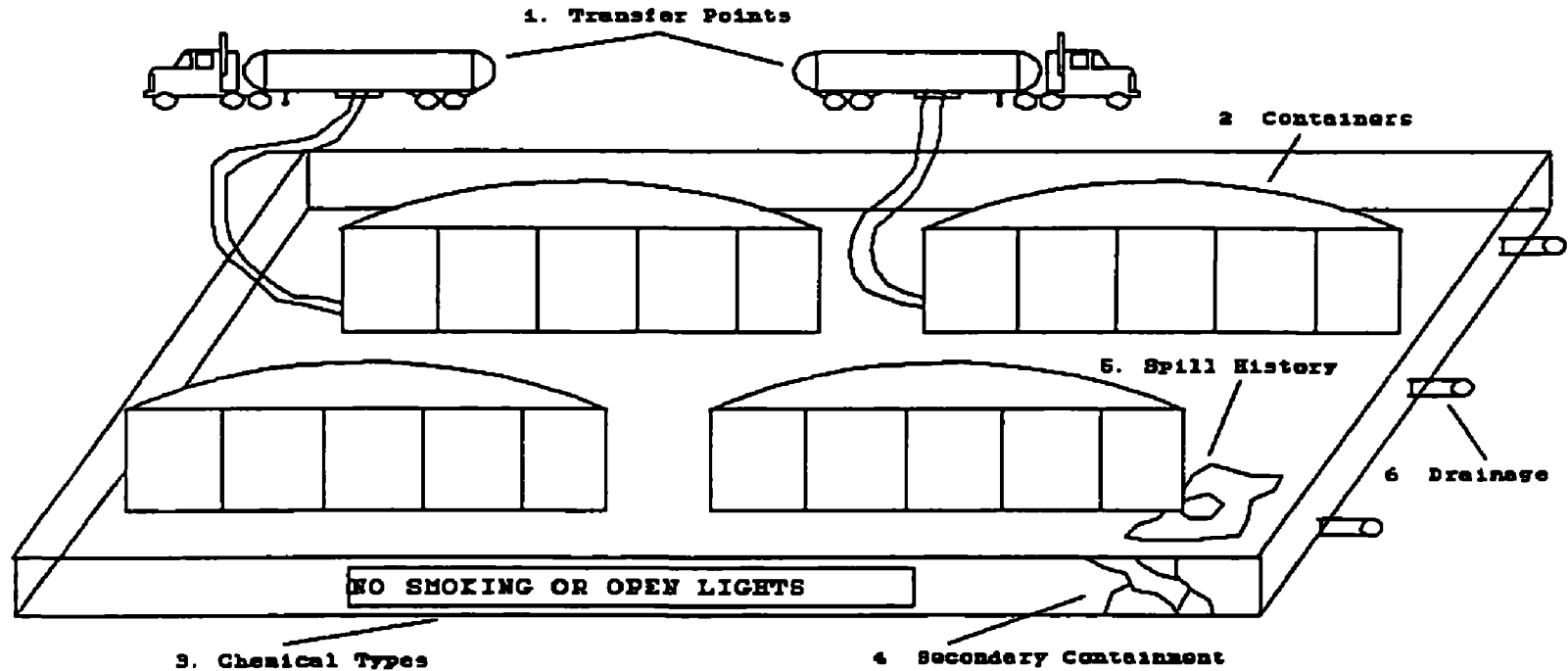
5. Community Access

- Look for evidence of trespassers onto the landfill.
- Look for children's play areas in the migration pathways of leachate.
- Find out if the community is aware of any actual or potential hazards posed by the landfill.
- Determine whether access to the landfill can be sufficiently restricted using signs or barriers.

6. Air Emissions

- Determine whether air emissions are controlled at the landfill.
- Check for emissions that can be detected with monitoring instruments.
- Determine whether prevailing winds carry contaminants into sensitive populations or environments.

HAZARD RECOGNITION - Chemical Storage



Chemical Storage Checklist

- Key Points and Potential Hazards -

1. Transfer Points

- Determine whether bulk chemical transfer was performed on a concrete pad or over soil/gravel.
- Look for any stained soil and stressed vegetation.
- Was vehicle decontamination performed? How were decontamination agents disposed of?
- Note the condition of pipes/hoses, fittings, valves, and joints.

2. Containers

- Determine whether containers are filled or empty.
- Is the container structure compatible with the stored chemical, if the contents are known?
- If the contents are unknown, do the composition and structure of each container give clues to the contents and its associated hazards?
- Look for such indicators of structural instability as weak welds, bulging panels, missing rivets, and so forth.
- Are access portals intact; can any leakage be observed?
- Can the containers be expected to remain intact until remediation is complete?

3. Chemical Types

- Research the toxic and physical properties of the stored chemicals.
- Do signs or markings on the containers provide clues to potential dangers?
- Are incompatible chemicals stored adjacent to one another?
- Do the stored chemicals have the potential to degrade into a more hazardous form?

4. Secondary Containment

- Calculate whether the containment volume is sufficient to hold the contents of the largest primary container plus freeboard.

- Determine whether the containment structure is compatible with the chemicals present.
- Is the containment structure totally enclosing, with four walls and a floor?
- Look for any breaches, whether intentional or otherwise, present in the secondary containment structure.
- Look for any drains present in the structure.

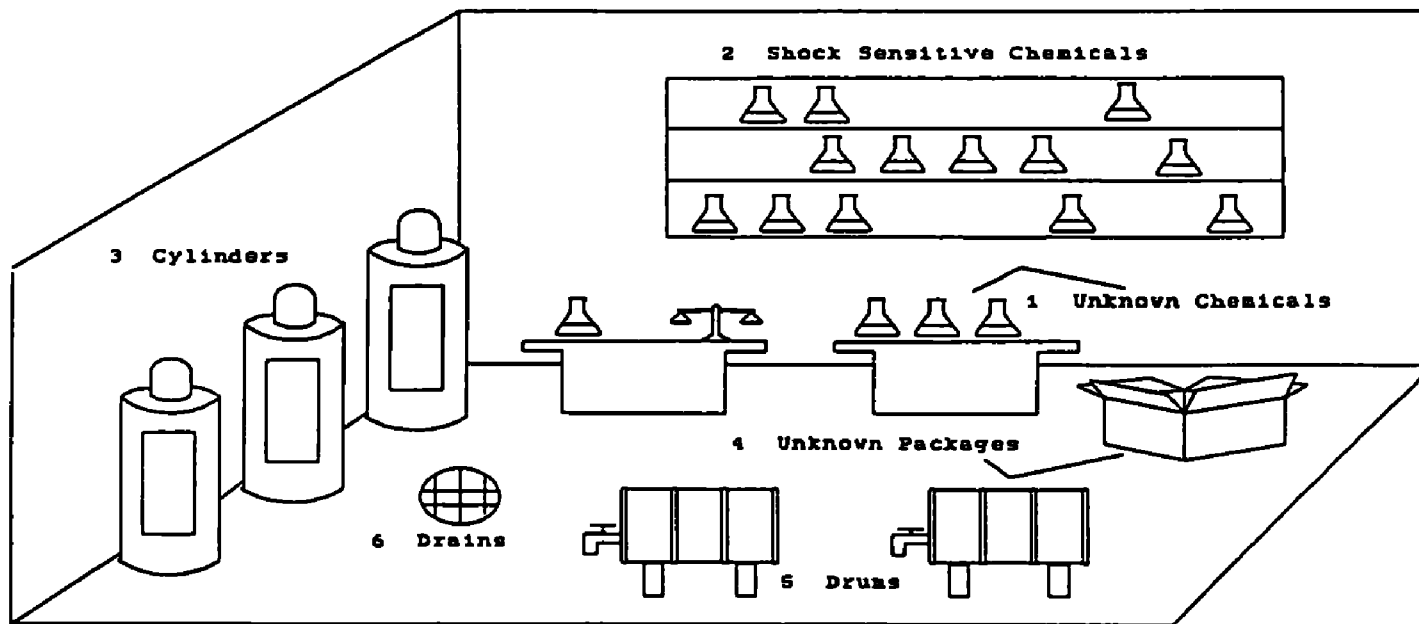
5. Spill History

- Determine whether spills were frequent during past operations.
- Do past spills have the continuing potential to migrate offsite?
- Have spills compromised the structures of either the primary containers or the secondary containment structure?

6. Drainage

- Determine whether the secondary containment structure is designed to allow for drainage of rainwater.
- Are drainage areas directed to sumps, to a treatment plant, or to the environment?
- Can the drains be blocked or otherwise closed?

HAZARD RECOGNITION - Laboratory



Laboratory Checklist

- Key Points and Potential Hazards -

1. Unknown Chemicals

- Over time, chemicals can degrade into different, more hazardous forms.
- Older labs may have used obsolete nomenclature, so labels and papers may be confusing.
- Often, handwritten labels may be incorrect.
- Packages may become unstable over time.
- Incompatible chemicals may be stored in close proximity.
- Instruments and tubing may still contain chemicals and chemical residues.

2. Shock Sensitive Chemicals

- Many chemicals, such as ethers, are peroxidizable and can be explosively shock sensitive.
- Shock sensitive chemicals can be detonated by falling off a shelf or by the shear force generated by turning the cap. Some chemicals can violently decompose spontaneously.
- Many common lab chemicals such as picric acid can, over time, become shock sensitive.

3. Cylinders

- Cylinders can contain either liquids or gases.
- They can be constructed for high pressure or low pressure use.
- Color coding is manufacturer specific and is not common to the industry.
- Cylinders can hold extremely toxic or corrosive materials.
- They should only be examined and moved by experts.
- Structural instability is not always visible from the exterior.

4. Unknown Packages

- Chemicals can be present in a variety of packaging, apart from the common flasks and glass bottles.

- Acid carboys are sometimes shipped in cardboard boxes or wooden crates.
- Radioactive materials can be shipped in metal flasks or small boxes.

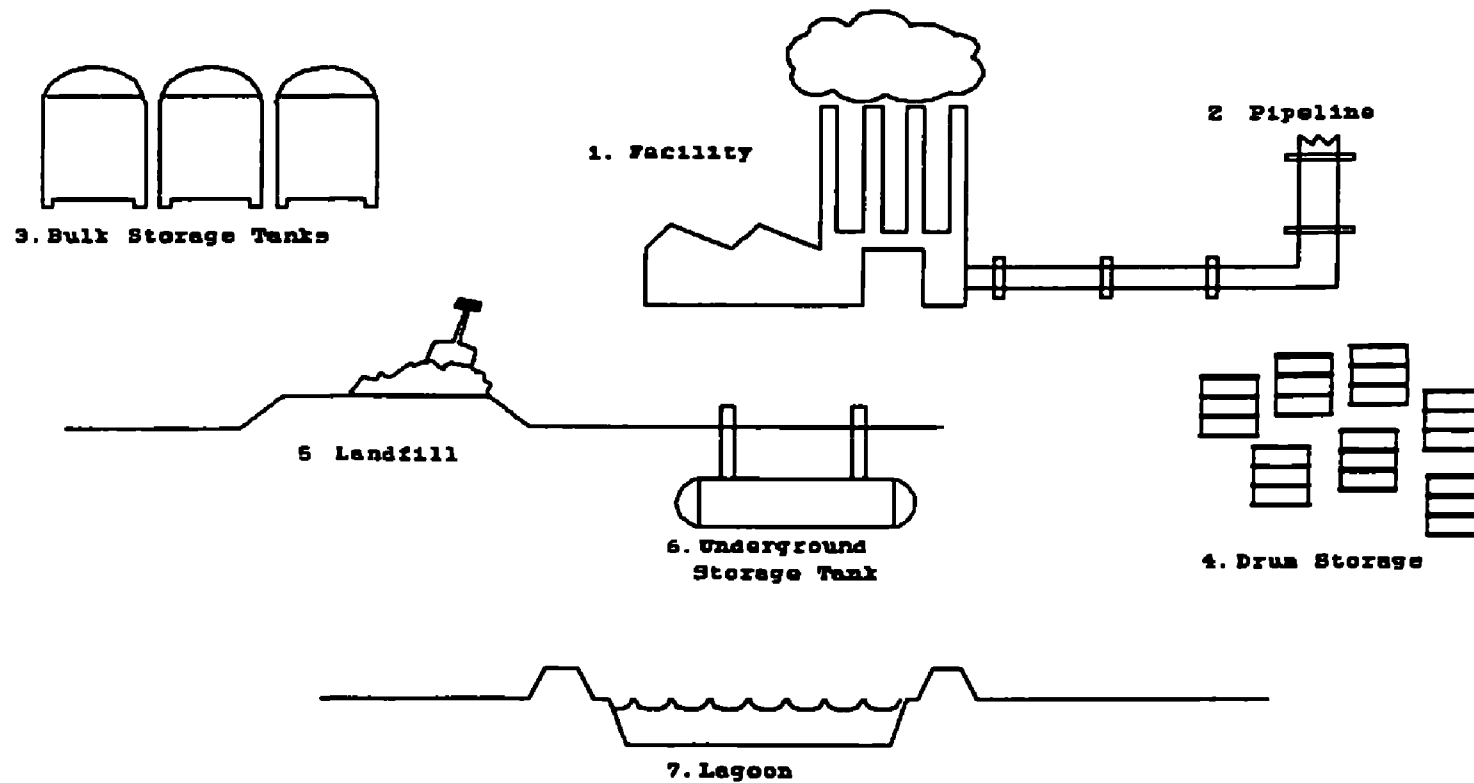
5. Drums

- Laboratories occasionally maintain chemicals in larger containers, such as 55-gallon drums.
- Larger volume chemicals would typically be caustic cleaners or solvents.
- These drums commonly rest on their sides, incorporate spigots, and have a high potential for leakage.
- Note the condition of the floor under any drums.

6. Drains

- Often chemicals are washed into floor drains.
- Determine whether drains are connected to sump pits or other potential containment areas.
- Are drain outfalls directed to a stream, river, or other sensitive area?
- Pools of chemicals may accumulate in sumps.
- Incompatible chemicals may generate toxic gases in drains, sumps, or drain lines.
- Outfalls for these drains should be examined for signs of contamination.

HAZARD RECOGNITION - Industrial Facility



Industrial Facility Checklist

- Key Points and Potential Hazards -

1. Facility

- Evaluate the structural stability of the building(s).
- Document whether asbestos or nonasbestos insulation was used.
- Document whether PCB or non-PCB transformers were used.
- Document whether process units are filled or empty, pressurized or nonpressurized.
- Note the presence of raw materials, byproducts, and wastes in addition to chemical products.
- Obtain the history of operations, past disposal practices, and chemical spills.

2. Pipelines

- Note the structural stability of interior piperacks and exterior feed pipes.
- Document whether asbestos or nonasbestos insulation was used.
- Note the compatibility of chemicals and pipe construction materials.
- Document whether pipelines or other types of tubing are filled or empty.
- Note the condition of valves, fittings, joints and so forth.
- Research the toxicity and physical properties of chemicals known to be used at the facility.

3. Bulk Storage Tanks

- Evaluate the structural stability of the outer skin and document any signs of physical or chemical deterioration.
- Document whether tanks are connected or disconnected to feed pipes.
- Document whether tanks are pressurized or nonpressurized, insulated or noninsulated.
- Note the condition of valves and fittings.
- Note the presence of additional heating or cooling systems to keep contents at a steady state.

- Research the toxicity and physical properties of stored chemicals.

4. Drum Storage

- Note the age of drums.
- Document whether drums are sheltered or exposed to the elements.
- Look for any signs of deterioration or stress.
- Look for any visible label or placard information.
- Look for any visible stencilled or handwritten information.
- The drum shape may potentially indicate the contents (i.e., acid carboy for corrosives or fiber drum for solids).
- If drum is bulging, determine whether bulging is due to built-up pressure or to thermal expansion/contraction.
- Document whether drums contain pure chemicals or waste materials.
- Look for any standing discolored water, stained soil, or stressed vegetation, any one of which may indicate spillage.
- Research the toxicity and physical properties of stored chemicals.

5. Landfill

- Determine whether the landfill is permitted or unpermitted.
- If permitted, document the materials known to be present.
- Research the past history of disposal practices.
- Determine whether the landfill is lined or unlined.
- Research the hydrogeology of the area and where the water table lies with respect to the landfill.
- Are there any monitoring or drinking water wells in the area?
- Research the toxicity and physical properties of chemicals present.

6. Underground Storage Tank

- Note the age of tank.
- Obtain the maintenance history.
- Research the hydrogeology of the area; note the location of the water table.
- Note the condition of exterior fittings.
- Note any seepage in the surrounding area.
- Research the toxicity and physical properties of stored chemicals.

- Document whether the tank is double lined or has cathodic corrosion protection.
- Look for evidence of frequent overflows.

7. Lagoon

- Note the stability of berm construction.
- Determine whether there is sufficient freeboard to avoid overflow.
- Is the lagoon lined or unlined?
- Research the toxicity and physical properties of chemicals present.
- Research the hydrogeology of the area; where does the water table lie with respect to the lagoon.
- Is secondary containment available?
- Note any standing discolored water, stained soil, or stressed vegetation in the area.
- Note any seepage through the berm.

What's Wrong With This Picture?

The map on page 47 is a modified version of a map of an actual Removal site. Look at the map in terms of the hazard recognition checklists, pick out the hazards, then rank them according to degree of threat to the site investigation team. What immediate threats does the site pose to the environment and to the health and welfare of any residents nearby? What long-term hazards are at the site? What clues to the level of threat should the investigation team look for onsite?

BACKGROUND

The All Cracked Up Battery Corp. smelted and refined lead extruded from used batteries to produce lead ingots. The facility operated for 10 years until it went bankrupt and was abandoned two years ago.

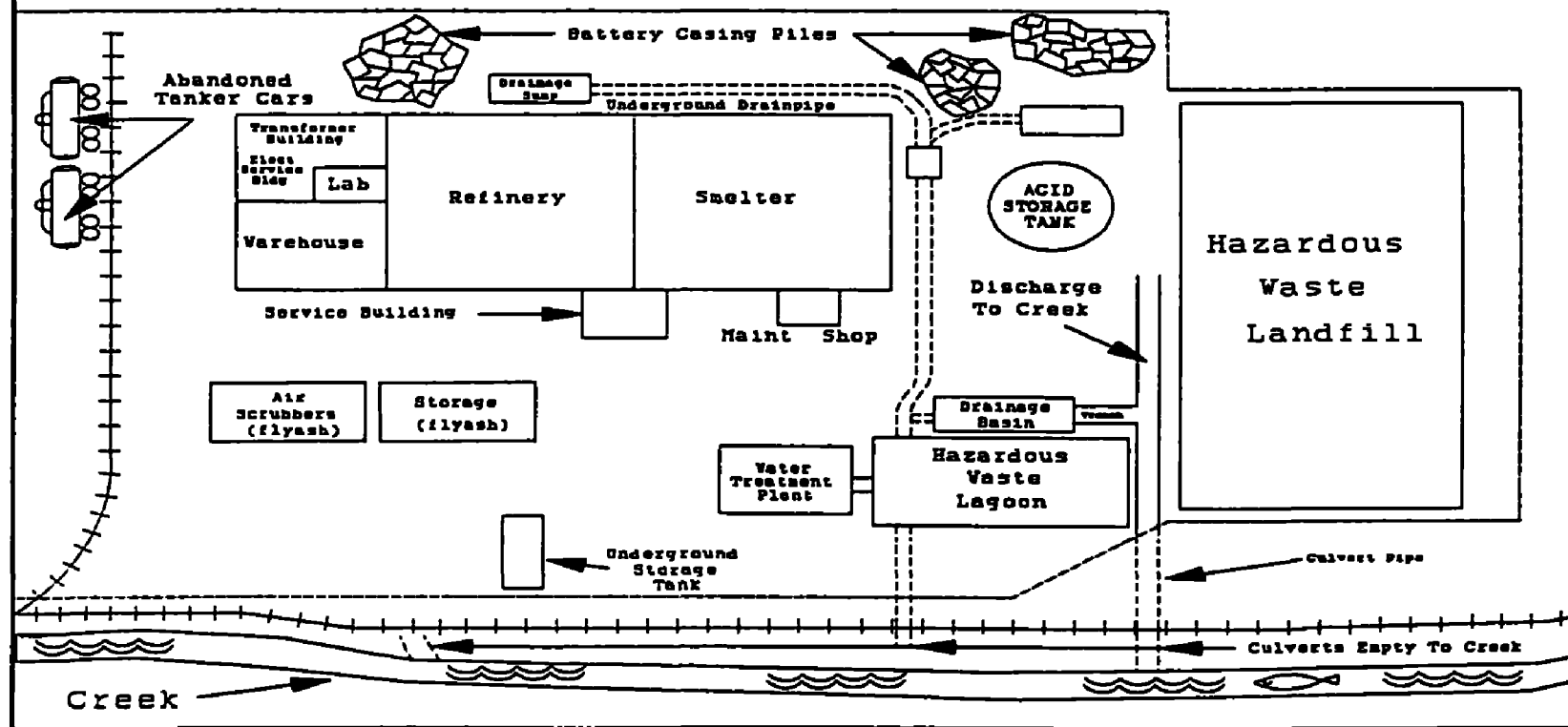
All Cracked Up received spent batteries of all sizes and had them dumped on a concrete pad to drain the acid. Battery acid and contaminated runoff from the pad were collected in a sump and then directed into a hazardous waste lagoon. After the acid was drained, the batteries were transported from the dumping area to a hammermill, which crushed them for materials separation and cleaning. Wastewater from the cleaning process was collected in a sump and directed to the lagoon. After separation of plastics and other unrecyclable materials, the metal component of the battery was smelted then refined. Emissions from smelters were scrubbed using a lime slurry and liquid from the lagoon. Residue from the scrubbing process was placed in a landfill onsite. Emissions from the smelters and refinery were also fed through a bag house. The flyash generated from this process was stored in a building onsite. The flyash contained heavy metals in the 3 percent concentration range.

Crushed battery casings from the hammermill were left in piles throughout the portion of the site north of the operations building and in the hazardous waste landfill along the east boundary fence. Surface runoff from the piles of battery casings was collected in a sump and directed to the lagoon, resulting in the migration of small battery casing chips into the sumps, drainage lines, and the lagoon itself.

The lagoon was treated with lime to neutralize its contents. Liquid from the lagoon passed into the water treatment plant, where it was treated with flocculants to remove heavy metals. The precipitates were disposed of in the landfill. The treated water was discharged into a nearby creek.

A site inspection by state officials revealed the presence of a trench between the collection sump and a drainage ditch, which facilitated the bypassing of the lagoon during periods of heavy surface runoff. Battery casing chips were found throughout the course of the drainage ditch and the creek downstream of the site.

All Cracked Up Battery Corp Site



Piles of battery casing chips

- What types of residues can you expect to be on the chips?
- Relate these residues to past industrial activities.
- How hazardous are these residues?
- Is there any evidence that residues on these chips are migrating from the piles, into the sumps, or offsite?
- How will extensive rainfall affect these piles?
- Is there vegetation around the piles; if so, in what condition is it?
- Is there any means by which persons could gain access to these piles, especially children?

Drainage sumps and underground drainpipe

- Runoff from the piles of battery casing chips flows to several drainage sumps and then into an underground drainpipe system. Is there standing water around the sumps?
- If so, is the water discolored and/or cloudy? Perform a pH test using pH paper.
- Are the drainpipes clogged?
- Where can surface runoff be expected to pool?
- Do winds generate excessive dusts? Dusts are most likely contaminated.

Liquid waste storage tank

- This container holds unknown waste material.
- Is there secondary containment around the tank? If so, is it sufficient to hold the contents of the tank?
- In what condition is the tank; is it corroded; does there appear to be structural instability?
- Is there evidence that the tank leaks?
- Is there stressed vegetation or discolored soil around the tank?
- If there is standing water near the tank, test it with a strip of litmus paper.
- Are there process lines to and from the tank? Perhaps they are underground. The lines may contain chemicals and chemical residues.
- Apply the checklist beginning on page 37 to help determine the hazards posed by the storage tank.

Hazardous waste landfill

- Is the landfill lined or unlined?
- Is there evidence of leachate seepage?
- If so, what color is the seepage; is it cloudy?
- How does the seepage test with pH paper?
- Is there access for liquids (precipitation) into the landfill?
- Did the company dispose of hazardous liquids in the landfill?
- Evaluate company records; remember that these may be deliberately incorrect.
- Is the landfill secure? Be sure that curious persons, particularly children, can not gain access.
- Use the checklist beginning on page 34 to help determine the hazards posed by the landfill.

Drainage basin and hazardous waste lagoon

- Are the drainage basin and lagoon each lined or unlined?
- How much freeboard does each one have?
- Are the process lines into each free of debris?
- Is there evidence that one or both impoundments has overflowed in the past?
- Is there standing water in the overflow trench?
- If so, what does the water look like; how does it test with pH paper?
- Are there battery casings in the overflow trench?
- Apply the checklist beginning on page 31 to the drainage basin and lagoon.

Underground storage tank

- Note the presence of seepage along banks of creek, which may be indicative of release from the storage tanks.
- Review company records. What type of fuel did the facility use? Where and how was it stored, transported and burned?
- Refer to the discussion on page 43 about chemical production facilities for additional hazards posed by USTs.

Air scrubbers and flyash storage

- Ensure that access to flyash storage is secure, particularly from curious children.
- Evaluate all piping, process lines and machinery for residual materials.
- Note the locations of drainage sumps and treatment tanks.
- Do winds generate excessive dusts? Dusts are most likely contaminated.

Abandoned tank cars

- These should be treated like storage tanks containing unknown chemicals.
- Look for any markings or placards on the outside of the cars that may indicate what they contain.
- Refer to Appendix 1 for silhouettes of railcars in order to determine what they may contain, e.g., pressurized gas, corrosive materials, etc.
- After identification, are incompatibles next to each other?
- Are the cars structurally sound and uncorroded?
- Do they appear to be leaking? Check ditches, puddles and culverts adjacent to tanks. Do they contain free-standing liquid? Test with pH paper.
- Apply the checklist beginning on page 37 to the tank cars.

Warehouse

- Locate drainage sumps, process lines, and utilities.
- Be aware of contaminated surfaces.
- Spent/old machinery poses additional hazards, e.g., laceration.
- Is the building properly ventilated; be aware of confined space entry hazards.
- Are materials stored in the warehouse? Identify materials if possible.
- Are incompatibles stored next to each other?
- Ensure that the building is structurally sound and that adequate lighting is available.
- Watch for slip, trip, and fall hazards.

Refinery/Smelter

- Ensure that the building and large equipment (kettles, cranes, hammermill) are structurally sound.
- Locate process lines and utilities.
- Most surfaces in this area will be contaminated.
- It is likely that the atmosphere in this area is also contaminated. Watch for confined space entry hazards.
- Watch for slip, trip and fall hazards.

Service Building/Maintenance Area

- Look for chemical hazards, e.g., cleaning agents, degreasers and associated solvents, stripping agents, lubricants, etc.
- Check for storage of incompatible materials.
- Old machinery is a potential source of injury.
- Most surfaces in this area will be contaminated.
- Note the presence of gas cyclinders.
- There may be a fire and explosion threat, particularly in areas with low ceilings and confined spaces.

Facility

- Thoroughly evaluate company records to be sure of industrial processes and all materials involved.
- Because this facility was involved in metals analysis and recycling, it is possible that industrial radiography may have been used. Look for radiation symbols; scan with rad meter if possible.
- How structurally sound is the building?
- What is the condition of the transformer room? Is there evidence of spilled oil, which could contain PCBs?
- What is the condition of the lab? Apply the checklist beginning on page 40 to the lab.
- How secure is the facility? Is there any evidence of entrance to the facility, e.g., vandalism, children playing?

Topographics

- Is the site upgradient or downgradient to established surface water flow patterns?
- Does surface water flow through the site?
- Consult a hydologist for groundwater concerns.

- Are there waterways nearby which may be affected?

Demographics

- What is the principal use of the land immediately adjacent to the site?
- How close is the nearest residence?
- Is there a possibility for offsite migration of contaminants to residential property?
- Are there any sensitive populations nearby, particularly children and the elderly?
- Does this site have the potential to affect the water supply of nearby residents?
- Are there any heavy use areas nearby, e.g., schools, industry, hospitals, shopping centers, farming, recreational areas, convalescent homes?
- Is there any other local industry which may have contributed to problems with this site?

After thoroughly evaluating all known aspects of the site, it is necessary to make a preliminary judgment about the degree of threat posed by this facility. At many sites, the conclusion will often be that the facility does pose a threat, but the threat should be thoroughly characterized to determine whether the site qualifies as a candidate for an emergency Removal action, or if the site is secure enough to wait for a Remedial action. Assistance in these decisions can be provided by review of the NCP. If the All Cracked Up Battery Site, or any other site, meets any of the criteria in the NCP for a Removal action, then site conditions may be considered an emergency situation. Emergency situations do not always involve the classic fire and explosions, or oil spills. Frequently, emergency actions involve the stabilization of a site until the Remedial Branch can completely characterize all threats associated with the site. Further assistance in emergency determination for a facility such as the one pictured here can be obtained through consultation with any of the Section Chiefs and On-Scene Coordinators (OSCs) in the Removal Branch.

Emergency Removal Guidelines

To help resolve incongruities in the screening process for determination of the necessity for removal actions, the EPA Region III Technical Support Section, through the efforts of toxicologist Dr. Roy L. Smith, has developed the following list of emergency removal trigger guidelines. This list was designed for use only as a screening tool to aid RPMs and OSCs in the characterization of emergency threats associated with uncontrolled hazardous waste sites. This list is by no means intended to be the sole foundation for cleanup decisions. Rather, it is meant to function as just one of many sources of information that the decision maker should rely upon. Users of the first edition of this handbook will note that the guidelines have been considerably revised, due to changes in the model used to generate the numeric values.

Toxicological values are listed in this table as absolute concentrations. That is, no calculations or manipulations of these values are necessary to use this list. To use this list, simply compare data from sampling analyses to concentrations on the list. If the results of an analysis are slightly below, equal to, or above the values listed in the table, then there is a possibility that an emergency health threat may be present at that particular site. In any situation involving the possibility of an emergency health threat, an EPA toxicologist should be consulted.

The toxicological values on this list were obtained through extensive research and evaluation of toxicological data bases, compiled through toxicity testing of the compounds, epidemiological studies, actual exposure incidences (i.e., workplace exposure, suicide attempts, accidental poisonings), and past experiences of the agency. Values derived from this broad range of investigative methods undergo review and verification before they are permitted to be published. This list, therefore, represents the most recent advances in toxicological determination and risk assessment.

We must emphasize, however, that this list has not undergone extensive peer review. It is intended for internal use only and should not be considered as EPA policy. Field personnel should use caution when referring to this list in any way that may imply EPA's endorsement of these values.

Assumptions Used in Calculating the Reference Levels

As the toxicology section of this guide explains, there is biological variation in all human populations, causing variation in the individual response to a particular dose of a toxin. Therefore, even though the response of the total population is predictable, the response of any one person within the exposed population is unpredictable. Certain assumptions about biological variation must be made to develop response models to assess risk and to predict response. The following assumptions are the basis of the model used to develop the reference values that begin on page 58:

- Carcinogen levels correspond to an upper bound lifetime risk of 1×10^{-4} . Noncarcinogen levels correspond to a hazard quotient of 10. The hazard quotient for drinking water is 1.
- Exposure comes from a single medium, except in the case of drinking water. In this case, concentrations are based on both intake of drinking water and inhalation of vapors, where appropriate.
- Exposure to residents continues for 30 years, but toxic effects from noncarcinogens may occur in as little as one year.

- For calculation purposes, adults weigh 70 kilograms and children weigh 15 kilograms; the life span is 70 years.
- Soil levels include only ingestion exposure; they omit inhalation and dermal contact.
- The amount of drinking water ingested is 2 liters per day. Compounds with Henry's Law constants greater than 10^{-4} atm m³/mol are substantially volatilized during household tap water use. Each ug/l in water produces an indoor air concentration of 0.5 ug/m³.
- Residential soil exposure for adults is based on consumption of 100 milligrams of soil per day, for 30 years. Consumption by children is 200 milligrams per day for 6 years.
- Industrial soil exposure is based on consumption of 100 milligrams of soil per day, 250 days per year, for 25 years.
- Adults inhale 20 cubic meters of air per day.
- Fish ingestion is 54 grams per day.
- Remember that these criteria are based on long-term exposure periods. Exposure to higher doses of toxic materials may produce adverse effects within a much shorter time frame, i.e., within days or weeks.

Following the list of emergency removal trigger guidelines is the list of removal numeric action levels for contaminated drinking water sites. This list was prepared by the U.S. EPA Office of Solid Waste and Emergency Response, Emergency Response Division and released in April 1991. The list reflects recent EPA and oral toxicity data and associated health criteria available for the listed chemicals. The toxicity data has been obtained from EPA's Integrated Risk Information System (IRIS), current up to February 1991, and EPA's Health Effects Assessment Summary Tables (HEAST), 4th quarter, 1991. The list also reflects the latest proposed maximum contaminant levels (MCLs) for 24 compounds (55 FR 30370, July 25, 1990).

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Acephate	150	98	36	33000	3100
Acetaldehyde	1100	110	41	37000	22000
Acetone	3700	3700	1400	1000000	78000
Acetonitrile	220	370	81	61000	4700
Acetophenone	3700	0 18	1400	1000000	78000
Acifluorfen	470	470	180	130000	10000
Acrolein	2900	2900	1100	820000	63000
Acrylamide	1 9	0 19	0 07	64	38
Acrylic acid	2900	3 1	1100	820000	63000
Acrylonitrile	16	3 5	0 58	530	320
Aflatoxin B1	0 0029	0 00029	0 00011	0 099	0 059
Alachlor	110	11	3 9	3500	2100
Alar	5500	5500	2000	1500000	120000
Aldicarb	2 6	2 6	0 95	720	55
Aldicarb sulfone	11	11	4 1	3100	230
Aldrin	0 5	0 05	0 019	17	10
Allyl	9100	9100	3400	2600000	200000
Allyl alcohol	180	180	68	51000	3900
Allyl chloride	180	10	68	51000	3900
Aluminum	110000	110000	39000	30000000	2300000
Aluminum phosphide	15	15	5 4	4100	310
Amdro	11	11	4 1	3100	230

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Amctryn	330	330	120	92000	7000
m-Aminophenol	2600	2600	950	720000	55000
4-Ammopyridine	0.73	0.73	0.27	200	16
Amitraz	91	91	34	26000	2000
Ammonia	0	1000	0	0	0
Ammonium sulfamate	7300	7300	2700	2000000	160000
Aniline	37	10	14	10000	780
Antimony and compounds	15	15	5.4	4100	310
Apollo	470	470	180	130000	10000
Aramite	340	34	13	11000	6800
Arsenic and compounds	4.9	0.017	0.18	160	97
Asulam	1800	1800	680	510000	39000
Atrazine	38	3.8	1.4	1300	770
Azobenzene	77	7.7	2.9	2600	1500
Barium and compounds	2600	5.1	950	720000	55000
Barium cyanide	2600	2600	950	720000	55000
Baygon	150	150	54	41000	3100
Bayleton	1100	1100	410	310000	23000
Baythroid	910	910	340	260000	20000
Benefin	11000	11000	4100	3100000	230000
Benomyl	1800	1800	680	510000	39000
Bentazon	91	91	34	26000	2000

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Benzaldehyde	3700	3700	1400	1000000	78000
Benzene	49	29	11	9900	5900
Benzidine	0.037	0.0037	0.0014	1.2	0.74
Benzoic acid	150000	150000	54000	41000000	3100000
Benzotrachloride	0.66	0.00028	0.024	22	13
Benzyl alcohol	11000	11000	4100	3100000	230000
Benzyl chloride	8.3	5	1.9	1700	1000
Beryllium and compounds	2	0.1	0.073	67	40
Bifrin	3.7	3.7	1.4	1000	78
Biphenitrim (Talstar)	550	550	200	150000	12000
1,1-Biphenyl	1800	1800	680	510000	39000
Bis(2-chloroethyl)ether	1.3	0.77	0.29	260	150
Bis(2-chloroisopropyl)ether	240	1500	540	410000	31000
Bis(chloromethyl)ether	0.0065	0.0039	0.0014	1.3	0.77
Bis(2-chloro-1-methylethyl) ether	120	12	4.5	4100	2400
Bis(2-ethylhexyl)adipate	26000	26000	9500	7200000	550000
Bis(2-ethylhexyl)phthalate (DEHP)	610	61	23	20000	12000
Bisphenol A	1800	1800	680	510000	39000
Boron	3300	3300	1200	920000	70000
Bromodichloromethane	11	6.6	2.4	2200	1300
Bromoethene	0.016	7.7	0	0	0

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Bromoform (tribromomethane)	120	220	40	36000	16000
Bromomethane	8 5	51	19	14000	1100
4-Bromophenyl phenyl ether	2100	2100	780	590000	45000
Bromophos	180	180	68	51000	3900
Bromoxynil	730	730	270	200000	16000
Bromoxynil octanoate	730	730	270	200000	16000
1,3-Butadiene	0	0 47	0	0	0
1-Butanol	3700	3700	1400	1000000	78000
Butylate	1800	1800	680	510000	39000
Butyl benzyl phthalate	7300	7300	2700	2000000	160000
Butylphthalyl butylglycolate	37000	37000	14000	10000000	780000
Cacodylic acid	110	110	41	31000	2300
Cadmium and compounds	18	0.14	6.8	5100	390
Caprolactam	18000	18000	6800	5100000	390000
Captafol	73	73	27	20000	1600
Captan	2400	240	90	82000	49000
Carbaryl	3700	3700	1400	1000000	78000
Carbazole	430	43	16	14000	8500
Carbofuran	180	180	68	51000	3900
Carbon disulfide	610	3700	1400	1000000	78000
Carbon tetrachloride	4 3	6.6	2 4	2200	550

EMERGENCY REMOVAL GUIDELINE CONCENTRATION

CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Carbosulfan	370	370	140	100000	7800
Carboxin	3700	3700	1400	1000000	78000
Chloral	73	73	27	20000	1600
Chloramben	550	550	200	150000	12000
Chlordane	2 2	0 66	0 24	220	47
Chlorimuron-ethyl	730	730	270	200000	16000
Chlorine dioxide	0	2.1	0	0	0
Chloroacetaldehyde	250	250	93	71000	5400
Chloroacetic acid	73	73	27	20000	1600
3-Chloroaniline	150	150	54	41000	3100
4-Chloroaniline	150	150	54	41000	3100
Chlorobenzene	39	210	270	200000	16000
Chlorobenzilate	730	730	270	200000	16000
p-Chlorobenzoic acid	7300	7300	2700	2000000	160000
4-Chlorobenzotrifluoride	730	730	270	200000	16000
2-Chloro-1,3-butadiene	210	1500	270	200000	16000
1-Chlorobutane	2400	15000	5400	4100000	310000
Chlorodibromomethane	17	10	3 8	3400	2000
2-Chloroethyl vinyl ether	150	910	340	260000	20000
Chloroform	21	11	52	47000	7800
4-Chloro-2-methylaniline	15	1.5	0 54	490	290

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
4-Chloro-2,2-methylaniline hydrochloride	19	1.9	0.69	620	370
beta-Chloronaphthalene	2900	2900	1100	820000	63000
o-Chloronitrobenzene	57	34	13	11000	6800
p-Chloronitrobenzene	79	47	18	16000	9500
2-Chlorophenol	180	180	68	51000	3900
2-Chloropropane	660	3300	0	0	0
Chlorothalonil	550	77	29	26000	12000
o-Chlorotoluene	120	730	270	200000	16000
Chlorpyrifos	110	110	41	31000	2300
Chlorpyrifos-methyl	370	370	140	100000	7800
Chlorthiophos	29	29	11	8200	630
Chlorpropham	7300	7300	2700	2000000	160000
Chlorsulfuron	1800	1800	680	510000	39000
Chromium III and compounds	37000	0.021	14000	10000000	780000
Chromium VI and compounds	180	0.021	68	51000	3900
Coal tars	0	0.39	0	0	0
Cobalt	0.37	10	0.14	100	7.8
Copper and compounds	1400	370	500	380000	29000
m-Cresol	1800	1800	680	510000	39000
o-Cresol	1800	3700	680	510000	39000

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
p-Cresol	1800	1800	680	510000	39000
Crotonaldehyde	4.5	0.45	0.17	150	90
Cumene	1500	1500	540	410000	31000
Cyanazine	73	73	27	20000	1600
Cyanides	730	730	270	200000	16000
Copper cyanide	2600	2600	950	720000	55000
Calcium cyanide	1500	1500	540	410000	31000
Hydrogen cyanide	730	730	270	200000	16000
Nickel cyanide	730	730	270	200000	16000
Potassium cyanide	1800	1800	680	510000	39000
Potassium silver cyanide	7300	7300	2700	2000000	160000
Silver cyanide	3700	3700	1400	1000000	78000
Zinc cyanide	1800	1800	680	510000	39000
Cyanogen	1500	1500	540	410000	31000
Cyanogen chloride	1800	1800	680	510000	39000
Cyclohexanone	30000	180000	68000	51000000	3900000
Cyclohexylamine	7300	7300	2700	2000000	160000
Cyhalothrin/Karate	180	180	68	51000	3900
Cyromazine	270	270	100	77000	5900
Dacthal	18000	18000	6800	5100000	390000
Dalapon	1100	1100	410	310000	23000
Danitol	18	18	6.8	5100	390

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m ³)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
2,4-DB	290	290	110	82000	6300
DDD	35	3.5	1.3	1200	710
DDE	25	2.5	0.93	840	500
DDT	18	2.5	0.93	840	390
Decabromodiphenyl ether	61	370	140	100000	7800
Decabromodiphenyl oxide	370	370	140	100000	7800
Demeton	1.5	1.5	0.54	410	31
Diallate	23	14	5.2	4700	2800
Diazinon	33	33	12	9200	700
1,4-Dibromobenzene	61	370	140	100000	7800
1,2-Dibromo-3-chloropropane	0.065	0.039	0.014	13	7.7
1,2-Dibromoethane	0.096	1.1	0.0037	3.4	2
Di-n-butyl phthalate	3700	3700	1400	1000000	78000
Dibutyl nitrosamine	1.6	0.16	0.058	53	32
Dicamba	1100	1100	410	310000	23000
1,2-Dichlorobenzene	550	3300	1200	920000	70000
1,3-Dichlorobenzene	540	3200	1200	910000	70000
1,4-Dichlorobenzene	59	35	13	12000	7100
3,3'-Dichlorobenzidine	19	1.9	0.7	640	380
1,4-Dichloro-2-butene	0	0.092	0	0	0
Dichlorodifluoromethane	1200	7300	2700	2000000	160000

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
1,1-Dichloroethane	610	3700	1400	1000000	78000
1,2-Dichloroethane (EDC)	16	9 4	3 5	3100	1900
1,1-Dichloroethylene	1 3	0 71	0 53	480	280
1,2-Dichloroethylene (cis)	61	370	140	100000	7800
1,2-Dichloroethylene (trans)	120	730	270	200000	16000
Dichloromethane	370	520	42	38000	23000
2,4-Dichlorophenol	110	110	41	31000	2300
4-(2,4-Dichlorophenoxy) butyric acid (2,4-DB)	290	290	110	82000	6300
2,4-Dichlorophenoxyacetic acid (2,4-D)	61	370	140	100000	7800
1,2-Dichloropropane	21	13	4 6	4200	2500
1,3-Dichloropropene	8 7	6 6	1 8	1600	230
2,3-Dichloropropanol	110	110	41	31000	2300
Dichlorvos	29	2 9	1 1	990	590
Dicofol	19	1 9	0 72	650	390
Dicyclopentadiene	0 44	2 2	410	310000	23000
Dieldrin	0 53	0 053	0 02	18	11
Diethanolntrosamine	3	0 3	0 11	100	61
Diethylene glycol, monoethyl ether	73000	73000	27000	20000000	1600000
Diethylformamide	4000	4000	1500	1100000	86000
Diethylnitrosamine	0 057	0 0057	0 0021	1 9	1.1

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m ³)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Diethyl phthalate	29000	29000	11000	820000	630000
Difenzoquat (Avenge)	2900	2900	1100	820000	63000
Disflubenzuron	730	730	270	200000	16000
Diisopropyl methylphosphonate	2900	2900	1100	820000	63000
Dimethipin	730	730	270	200000	16000
Dimethoate	73	73	27	2000	160
3,3'-Dimethoxybenzidine	610	61	23	20000	12000
Dimethylamine	0	0.21	0	0	0
N,N-Dimethylaniline	73	73	27	20000	1600
3,3'-Dimethylbenzidine	0.93	0.093	0.034	31	19
1,2-Dimethylhydrazine	0.0061	0.00061	0.00023	0.2	0.12
N,N-Dimethylformamide	3700	310	1400	1000000	78000
Dimethylnitrosamine	0.17	0.017	0.0062	5.6	3.3
2,4-Dimethylphenol	730	730	270	200000	16000
2,6-Dimethylphenol	22	22	8.1	6100	470
3,4-Dimethylphenol	37	37	14	10000	780
Dimethyl terephthalate	3700	3700	1400	1000000	78000
4,6-Dinitro-o-cyclohexyl phenol	73	73	27	20000	1600
1,3-Dinitrobenzene	37	37	14	1000	78
1,2-Dinitrobenzene	11	11	4.1	3100	230
1,4-Dinitrobenzene	11	11	4.1	3100	230

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
2,4-Dinitrophenol	73	73	27	20000	1600
Dinitrotoluene mixture	13	13	0.46	420	250
2,6-Dinitrotoluene	13	13	0.46	420	250
Dinoseb	37	37	14	10000	780
1,4-Dioxane	770	77	29	26000	15000
Diphenamid	1100	1100	410	310000	23000
N,N-Diphenylamine	910	910	340	260000	20000
1,2-Diphenylhydrazine	11	11	0.39	360	210
Dipropylnitrosamine	12	0.12	0.045	41	24
Diquat	80	80	30	22000	1700
Direct black 38	0.98	0.098	0.036	33	20
Direct blue 6	11	0.11	0.039	35	21
Direct brown 35	0.92	0.092	0.034	31	18
Disulfoton	15	15	0.54	410	31
Diuron	73	73	27	20000	1600
Dodine	150	150	54	41000	3100
Endosulfan	1.8	1.8	0.68	510	39
Endothall	730	730	270	200000	16000
Endrin	11	11	4.1	3100	230
Epichlorohydrin	73	73	27	20000	1600
EPTC	910	910	340	260000	20000

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Ethephon (2-chloroethylphosphonic acid)	180	180	68	51000	3900
Ethion	18	18	6 8	5100	390
2-Ethoxyethanol	15000	2100	5400	4100000	310000
2-Ethoxyethanol acetate	11000	11000	4100	3100000	230000
Ethyl acetate	33000	33000	12000	9200000	700000
Ethyl acrylate	180	18	6 6	6000	3500
Ethylbenzene	610	3700	1400	1000000	78000
S-Ethyl dipropylthiocarbamate	910	910	340	260000	20000
Ethylene cyanohydrin	11000	11000	4100	3100000	230000
Ethylene diamine	730	730	270	200000	16000
Ethylene dibromide (EDB)	0 035	0 021	0 0077	7	4 2
Ethylene glycol	73000	73000	27000	20000000	1600000
Ethylene glycol, monobutyl ether	0	210	0	0	0
Ethylene oxide	0	2 4	0	0	0
Ethylene thiourea (ETU)	2 9	2 9	1 1	820	63
Ethyl chloride	710	100000	270	200000	16000
Ethyl ether	1200	7300	2700	2000000	160000
Ethyl methacrylate	3300	3300	1200	920000	70000
Ethyl p-nitrophenyl phenylphosphorothioate	0 37	0 37	0 14	100	7 8

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
1-Ethyl-nitrosourca	0.26	0.026	0.0096	8.7	5.2
Ethylphthalyl ethyl glycolate	110000	110000	41000	31000000	2300000
Fenamiphos	9.1	9.1	3.4	2600	200
Fluometuron	470	470	180	130000	10000
Fluorides	2200	2200	810	610000	47000
Fluoridone	2900	2900	1100	820000	63000
Fluvalinate	370	370	140	100000	7800
Folpet	2400	240	90	82000	49000
Fomesafen	45	4.5	1.7	1500	900
Fonofos	73	73	27	20000	1600
Formaldehyde	280	19	11	9500	5700
Formic Acid	73000	73000	27000	20000000	1600000
Fosetyl-al	110000	110000	41000	31000000	2300000
Furan	37	37	14	10000	780
Furazolidone	2.2	0.22	0.083	75	45
Furfural	110	370	41	31000	2300
Furum	0.17	0.017	0.0063	5.7	3.4
Glufosinate-ammonium	15	15	5.4	4100	310
Glycidaldehyde	15	15	5.4	4100	310
Glyphosate	3700	3700	1400	1000000	78000
Haloxypop-methyl	1.8	1.8	0.68	510	39
Heptachlor	0.32	0.19	0.07	64	38

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m ³)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Heptachlor epoxide	0.18	0.33	0.12	110	23
Hexabromobenzene	0.079	0.094	0.035	31	10
Hexachlorobenzene	0.88	0.53	0.2	180	110
Hexachlorobutadiene	12	11	4	3700	1600
HCCH (alpha)	1.4	0.14	0.05	45	27
HCCH (beta)	4.7	0.47	0.18	160	95
HCCH (gamma) Lindane	6.4	0.64	0.24	220	130
HCCH-technical	4.7	0.47	0.18	160	95
Hexachlorocyclopentadiene	0.15	0.73	95	72000	5500
Hexachlorodibenzo-p-dioxin mixture (HxCDD)	0.0014	0.00014	0.000051	0.046	0.027
Hexachloroethane	6.1	37	14	10000	780
Hexachlorophene	11	11	4.1	3100	230
Hexamethyl phosphoramide (HMPA)	0	12	0	0	0
n-Hexane	350	2100	810	610000	47000
Hexazinone	1200	1200	450	340000	26000
Hydrazine, hydrazine sulfate	2.8	0.05	0.11	95	57
Hydrogen chloride	0	73	0	0	0
Hydrogen sulfide	110	9.4	41	31000	2300
p-Hydroquinone	1500	1500	540	410000	31000
Imazalil	470	470	180	130000	10000
Imazaquin	9100	9100	3400	2600000	200000

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m ³)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Iprodione	1500	1500	540	410000	31000
Iron and compounds	0	310	0	0	0
Isobutanol	11000	11000	4100	3100000	230000
Isophorone	2100	210	77	70000	42000
Isopropalin	550	550	200	150000	12000
Keponc	2.5	0.25	0.093	84	50
Lactofen	73	73	27	20000	1600
Lead (inorganic)	5.1	16	1.9	1400	110
Lead (as carcinogen)	210	21	7.9	7200	4300
Lead (alkyl)	0.0037	0.0037	0.0014	1	0.078
Linuron	73	73	27	20000	1600
Lithium	730	730	270	200000	16000
Malathion	730	730	270	200000	16000
Maleic anhydride	3700	3700	1400	1000000	78000
Maleic hydrazide	18000	18000	6800	5100000	390000
Malononitrile	0.73	0.73	0.27	200	16
Mancozeb	1100	1100	410	310000	23000
Maneb	180	180	68	51000	3900
Manganese and compounds	3700	4.2	1400	1000000	78000
Mephosfolan	3.3	3.3	1.2	920	70
Mercury and compounds (alkyl)	11	3.7	4.1	3100	230

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m ³)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Mercury and compounds (inorganic)	73	1.9	27	20000	1600
Mercury fulminate	110	110	41	31000	2300
Merphos	1.1	1.1	0.41	310	23
Merphos oxide	1.1	1.1	0.41	310	23
Metolaxyl	2200	2200	810	610000	47000
Methacrylonitrile	3.7	7.3	1.4	1000	78
Methamidophos	1.8	1.8	0.68	510	39
Methanol	18000	18000	6800	5100000	390000
Methidathion	37	37	14	10000	780
Methomyl	910	910	340	260000	20000
Methoxychlor	180	180	68	51000	3900
2-Methoxyethanol	37	210	14	10000	780
2-Methoxyethanol acetate	73	73	27	20000	1600
2-Methoxy-5-nitroaniline	190	19	6.9	6200	3700
Methyl acetate	37000	37000	14000	10000000	780000
Methyl acrylate	1100	1100	410	310000	23000
2-Methylaniline	35	3.5	1.3	1200	710
2-Methylaniline hydrochloride	47	4.7	1.8	1600	950
Methyl bromide	8.5	51	19	14000	1100
Methyl chloride	110	68	25	23000	14000
Methyl chlorocarbonate	37000	37000	14000	10000000	780000

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
2-Methyl-4-chlorophen- oxyacetic acid	18	18	6.8	5100	390
2-(2-Methyl-4-chlorophen- oxy)butyric acid (MCPB)	370	370	140	100000	7800
2-(2-Methyl-1,4-chlorophen- oxy)propionic acid (MCPB)	37	37	14	10000	780
4,4'-Methyldiphenyl isocyanate	0.1	0.52	0	0	0
4,4'-Methylenebisbenzyl- amine	34	3.4	1.3	1100	680
4,4'-Methylene bis(2-chloroaniline)	26	6.6	2.4	2200	550
4,4'-Methylene bis(N,N'-dimethyl)aniline	190	19	6.9	6200	3700
Methylene bromide	61	370	140	100000	7800
Methyl ethyl ketone	1800	8000	680	510000	39000
Methyl ethyl ketone peroxide	290	290	110	82000	6300
Methyl isobutyl ketone	1800	1800	680	510000	39000
Methyl methacrylate	2900	2900	1100	820000	63000
Methyl parathion	9.1	9.1	3.4	2600	200
Methyl styrene (mixture)	55	370	81	61000	4700
Methyl styrene (alpha)	4300	26000	9500	7200000	550000
Methylnitrosourea	0.028	0.0028	0.0011	0.95	0.57
Methyl tertbutyl ether (MTBE)	180	180	68	51000	3900

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Metolacior (Dual)	5500	5500	2000	1500000	120000
Metribuzin	910	910	340	260000	20000
Mirex	0.073	0.073	0.027	20	1.6
Mirex (as carcinogen)	4.7	0.47	0.18	160	95
Molinate	73	73	27	20000	1600
Molybdenum	150	150	54	41000	3100
Monochlorobutanes	15000	15000	5400	4100000	310000
Naled	73	73	27	20000	1600
Napropamide	3700	3700	1400	1000000	78000
Nickel and compounds	730	0.72	270	200000	16000
Nickel refinery dust	0	1	0	0	0
Nickel subsulfide	0	0.5	0	0	0
Nitrapyrin	55	55	20	15000	1200
Nitrate	58000	58000	22000	16000000	1300000
Nitric oxide	3700	3700	1400	1000000	78000
Nitrite	3700	3700	1400	1000000	78000
2-Nitroaniline	110	110	41	31000	2300
3-Nitroaniline	110	110	41	31000	2300
4-Nitroaniline	110	110	41	31000	2300
Nitrobenzene	18	22	6.8	5100	390
Nitrofurantoin	2600	2600	950	720000	55000
Nitrofurazone	5.7	0.57	0.21	190	110

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Nitrogen Dioxide	37000	37000	14000	10000000	780000
Nitroguanidine	3700	3700	1400	1000000	78000
4-Nitrophenol	2300	2300	840	630000	48000
2-Nitropropane	0	0.091	0	0	0
N-Nitrosodi-n-butylamine	1.6	0.16	0.058	53	32
N-Nitrosodiethanolamine	3	0.3	0.11	100	61
N-Nitrosodiethylamine	0.057	0.0057	0.0021	1.9	1.1
N-Nitrosodimethylamine	0.17	0.017	0.0062	5.6	3.3
N-Nitrosodiphenylamine	1700	170	64	58000	35000
N-Nitrosodi-n-propylamine	1.2	0.12	0.045	41	24
N-Nitroso-N-methylethyl- amine	0.39	0.039	0.014	13	7.7
N-Nitrosopyrrolidine	4.1	0.41	0.15	140	81
Nitrotoluenes (o-,m-,p-)	370	370	140	100000	7800
Norflurazon	1500	1500	540	410000	31000
Octabromodiphenyl ether	110	110	41	31000	2300
Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine (HMX)	1800	1800	680	510000	39000
Octamethylpyrophosphor- amine	73	73	27	20000	1600
Oryzalin	1800	1800	680	510000	39000
Osmium tetroxide	0.37	0.37	0.14	100	7.8
Oxadiazon	180	180	68	51000	3900

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Oxamyl	910	910	340	260000	20000
Oxyfluorfen	110	110	41	31000	2300
Paclobutrazol	470	470	180	130000	10000
Paraquat	160	160	61	46000	3500
Parathion	220	220	81	61000	4700
Pebulate	1800	1800	680	510000	39000
Pendimethalin	1500	1500	540	410000	31000
Pentabromodiphenyl ether	73	73	27	20000	1600
Pentachlorobenzene	49	29	11	8200	630
Pentachloronitrobenzene	18	110	41	31000	2300
Pentachlorophenol	71	7.1	26	2400	1400
Permethrin	1800	1800	680	510000	39000
Phenmedipham	9100	9100	3400	2600000	200000
Phenol	22000	22000	8100	6100000	470000
Phenyl mercuric acetate	29	2.9	11	820	63
m-Phenylenediamine	220	220	81	61000	4700
Phosmet	730	730	270	200000	16000
Phosphine	11	11	4.1	3100	230
Phosphorus (white)	0.73	0.73	0.27	200	16
p-Phthalic acid	37000	37000	14000	10000000	780000
Phthalic anhydride	73000	73000	27000	20000000	1600000
Picloram	2600	2600	950	720000	55000

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Pirimphos-methyl	370	370	140	100000	7800
Polybrominated biphenyls	0.26	0.096	0.035	32	5.5
Polychlorinated biphenyls (PCBs)	1.1	0.11	0.041	37	22
Polychlorinated terphenyls (PCTs)	1.9	0.19	0.07	64	38
Polynuclear aromatic hydrocarbons	0	0	0	0	0
Acenaphthene	2200	2200	810	610000	47000
Anthanthrene	2.3	0.44	0.086	78	46
Anthracene	11000	11000	4100	3100000	230000
Benz[a]anthracene	5.1	0.96	0.19	170	100
Benzo[b]fluoranthene	5.3	1	0.2	180	110
Benzo[j]fluoranthene	12	2.3	0.45	410	240
Benzo[k]fluoranthene	11	2.1	0.42	380	220
Benzo[ghi]perylene	34	6.3	1.2	1100	670
Benzo[a]pyrene	0.74	0.14	0.027	25	15
Benzo[c]pyrene	190	35	6.9	6200	3700
Cyclopentadieno[cd]pyrene	32	6.1	1.2	1100	640
Chrysene	170	32	6.2	5700	3400
Dibenz[ah]anthracene	0.67	0.13	0.025	22	13
Fluoranthene	1500	1500	540	410000	31000
Fluorene	1500	1500	540	410000	31000

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Indeno[1,2,3-cd]pyrene	3.2	0.6	0.12	110	64
Naphthalene	150	150	54	41000	3100
Phenanthrene	1100	1100	390	300000	23000
Pyrene	9.1	1.7	0.34	310	180
Pyridine	37	37	14	10000	780
Prochloraz	57	5.7	2.1	1900	1100
Profluralin	220	220	81	61000	4700
Prometon	550	550	200	150000	12000
Prometryn	150	150	54	41000	3100
Pronamide	2700	2700	1000	770000	59000
Propachlor	470	470	180	130000	10000
Propanil	180	180	68	51000	3900
Propargite	730	730	270	200000	16000
Propargyl alcohol	73	73	27	20000	1600
Propazine	730	730	270	200000	16000
Propham	730	9.4	270	200000	16000
Propiconazole	470	470	180	130000	10000
Propylene glycol	730000	730000	270000	2.00e+08	16000000
Propylene glycol, monoethyl ether	26000	26000	9500	7200000	550000
Propylene glycol, monomethyl ether	26000	18000	9500	7200000	550000

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m ³)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Propylene oxide	35	66	13	1200	710
Pursuit	9100	9100	3400	2600000	200000
Pydrin	910	910	340	260000	20000
Quinalphos	18	18	68	5100	390
Radium 226,228	240000	24000	8800	7900000	4700000
Radon 222	4000000	470000	0	0	0
RDX (Cyclonite)	77	77	29	2600	1500
Ronnel	1800	1800	680	510000	39000
Selenious acid	110	110	41	31000	2300
Selenium	110	110	41	31000	2300
Selenourea	180	180	68	51000	3900
Sethoxydim	3300	3300	1200	920000	70000
Silver and compounds	110	110	41	31000	2300
Simazine	71	71	26	2400	1400
Sodium acifluorfen	470	470	180	130000	10000
Sodium azide	150	150	54	41000	3100
Sodium cyanide	1500	1500	540	410000	31000
Sodium diethyldithiocarbamate	1100	1100	410	310000	23000
Sodium fluoroacetate	0.73	0.73	0.27	200	16
Sodium metavanadate	37	37	14	10000	780
Strychnine	11	11	4.1	3100	230

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m ³)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Styrene	47	28	11	9500	5700
2,3,7,8-TCDD (Dioxin)	0 000055	0 000006	0 000002	0 0018	0 0011
Tebuthiuron	2600	2600	950	720000	55000
Temephos	730	730	270	200000	16000
Terbacil	470	470	180	130000	10000
Terbufos	3 7	3 7	1 4	1000	78
1,2,4,5-Tetrachlorobenzene	1 8	11	4 1	3100	230
1,1,1,2-Tetrachloroethane	55	33	12	11000	6600
1,1,2,2-Tetrachloroethane	7.1	4 3	1 6	1400	850
Tetrachloroethylene (PCE)	61	370	6.2	5600	3300
2,3,4,6-Tetrachlorophenol	1100	1100	410	310000	23000
p,a,a,a-Tetrachlorotoluene	0 071	0 043	0 016	14	8 5
Tetrachlorovinphos	1100	1100	410	310000	23000
Tetraethyl lead	0 00061	0 0037	0 0014	1	0 078
Tetrahydrofuran	73	73	27	20000	1600
2,3,5,6-Tetrachloroterephthalate (DCPA)	18000	18000	6800	5100000	390000
Thallic oxide	15	15	5 4	4100	310
Thallium acetate	3 3	3 3	1 2	920	70
Thallium (soluble salts)	2 6	2 6	0 95	720	55
Thallium carbonate	2 9	2 9	1.1	820	63
Thallium chloride	2 9	2 9	1.1	820	63

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Thallium nitrate	3 3	3 3	1 2	920	70
Thallium selenite	3 3	3 3	1 2	920	70
Thallium sulfate	2 9	2 9	1 1	820	63
Thiobencarb	370	370	140	100000	7800
2-(Thiocyanomethylthio)- benzothiazole (TCMTB)	1100	1100	410	310000	23000
Thiofanox	11	11	4 1	3100	230
Thiophanate-methyl	2900	2900	1100	820000	63000
Thiram	180	180	68	51000	3900
Tin and compounds	22000	22000	8100	6100000	470000
Toluene	2700	21000	2700	2000000	160000
Toluene-2,4-diamine	2 7	0 27	0 099	89	53
Toluene-2,5-diamine	22000	22000	8100	6100000	470000
Toluene-2,6-diamine	7300	7300	2700	2000000	160000
o-Toluidene	35	3 5	1 3	1200	710
p-Toluidene	45	4 5	1 7	1500	900
Toxaphene	7 7	0 77	0 29	260	150
Triallate	470	470	180	130000	10000
Trasulfuron	370	370	140	100000	7800
1,2,4-Tribromobenzene	30	180	68	51000	3900
Tributyltin oxide (TBTO)	1 1	1 1	0 41	310	23
1,2,4-Trichlorobenzene	15	110	18	13000	1000

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
1,1,1-Trichloroethane	550	3300	1200	920000	70000
1,1,2-Trichloroethane	25	15	5.5	5000	3000
Trichloroethylene (TCE)	89	50	29	26000	15000
Trichlorofluoromethane	1800	11000	4100	3100000	230000
2,4,5-Trichlorophenol	430	43	16	14000	8500
2,4,6-Trichlorophenol	770	77	29	26000	15000
2,4,5-Trichlorophenoxy- acetic Acid	370	370	140	100000	7800
1,1,2-Trichloropropane	30	180	68	51000	3900
1,2,3-Trichloropropane	37	220	81	61000	4700
1,2,3-TCP as carcinogen	14	8.5	3.2	2900	1700
1,2,3-Trichloropropene	30	180	68	51000	3900
1,1,2-Trichloro-1,2,2- trifluoroethane	180000	1100000	410000	3.10e+08	23000000
Tridiphenyl	110	110	41	31000	2300
Triethylamine	0	7300	0	0	0
Trifluralin	270	110	41	37000	5900
Trimethyl phosphate	230	23	8.5	7700	4600
1,3,5-Trinitrobenzene	1.8	1.8	0.68	510	39
Trinitrophenylmethyl- nitramine	370	370	140	100000	7800
Trinitrotoluene (TNT)	7.3	7.3	2.7	2000	160
2,4,6-Trinitrotoluene	18	18	6.8	5100	390

EMERGENCY REMOVAL GUIDELINE CONCENTRATION					
CONTAMINANT	Drinking Water (ug/l)	Air Inhalation (ug/m3)	Fish Ingestion (mg/kg)	Worker Soil Ingestion (mg/kg)	Resident Soil Ingestion (mg/kg)
Uranium (natural)	0	0	0	0	0
Uranium (soluble salts)	110	110	41	31000	2300
Vanadium	260	260	95	72000	5500
Vanadium pentoxide	330	330	120	92000	7000
Vanadyl sulfate	730	730	270	200000	16000
Vernam	37	37	14	10000	780
Vernolate	37	37	14	10000	780
Vinclozolin	910	910	340	260000	20000
Vinyl acetate	37000	2100	14000	10000000	780000
Vinyl chloride	2.5	2.9	0.17	150	90
Warfarin	11	11	4.1	3100	230
m-Xylene	1400	7300	27000	20000000	1600000
o-Xylene	1400	7300	27000	20000000	1600000
Xylene (mixed)	2800	15000	27000	20000000	1600000
Zinc	7300	7300	2700	2000000	160000
Zinc phosphide	11	11	4.1	3100	230
Zincb	1800	1800	680	510000	39000

NOTE: When the numerical values were generated, no attempt was made to stop a calculation greater than the total concentration. This means, for example, that if a compound has a worker soil ingestion value over 1 million mg/kg, then from an emergency perspective the compound does not pose a toxic threat to workers via soil ingestion. Values over the total concentration are useful in comparing the relative toxicity of several compounds.

REMOVAL NUMERIC ACTION LEVELS FOR CONTAMINATED DRINKING WATER SITES
(April 8, 1991)

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Chemical ORGANICS	CAS#	Volatile (a)	MCL (ug/L)	DWEL (ug/L) (h)	WOE Class (i)	1E-4 RSC (ug/L) (j)	10-DAY HA (ug/L) (k)	Removal Action Level (ug/L)
Acetone	67641	Y	-	3,500.00	D	-	-	1,800
Acifluorfen (Tackle)	62476599	-	-	455.00	-	-	2,000.00	460
Acrylamide (2-Propenamide)	79061	-	1.0 (b)	7.00	B2	0.78	300.00	0.78
Acrylonitrile	107131	Y	-	-	B1	6.48	20.00	6.5
Adipates (Diethylhexyl)	103231	-	500 (e)	-	-	-	-	-
Alachlor	15972608	-	2 (b)	350.00	B2	43.00	100.00	43
Aldicarb (Temuk)	116063	-	10 (b)	2.45	D	-	10.00	2.5 (o)
Aldicarb sulfone	1646884	-	40 (b)	10.50	-	-	60.00	11 (o)
Aldicarb sulfoxide	-	-	10 (b)	-	-	-	10.00	-
Aldrin	309002	-	-	1.05	B2	0.21	0.30	0.21
Ametyrn	834128	-	-	315.00	-	-	9,000.00	320
Ammonia	7664417	-	-	34,000.00	-	-	-	34,000
Ammonium sulfamate	7773060	-	-	7,000.00	-	-	20,000.00	7,000
Anthracene	120127	-	-	10,500.00	D	-	-	11,000
Atrazine	1912249	-	3 (b)	175.00	-	-	100.00	180 (n)
Baygon	114261	-	-	140.00	-	-	40.00	140 (n)
Bentazon	25057890	-	-	87.50	-	-	300.00	88
Benz(a)anthracene	56553	-	0.1 (e;s)	-	B2	-	-	-
Benzene	71432	Y	5 (c)	-	A	120.69	200.00	121
Benzo(a)pyrene	50328	-	0.2 (e)	-	B2	-	-	-

REMOVAL NUMERIC ACTION LEVELS FOR CONTAMINATED DRINKING WATER SITES
(April 8, 1991)

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Chemical ORGANICS	CAS#	Volatile (a)	MCL (ug/L)	DWEL (ug/L) (h)	WOE Class (i)	1E-4 RSC (ug/L) (j)	10-DAY HA (ug/L) (k)	Removal Action Level (ug/L)
Benzo(b)fluoranthene	205992	-	0.2(e;s)	-	B2	-	-	-
Benzo(k)fluoranthene	207089	-	0.2(e;s)	-	B2	-	-	-
Bis(2-chloroisopropyl)ether	108601	Y	-	1,400.00	-	-	4,000.00	700
Bromacil	314409	-	-	-	-	-	5,000.00	-
Bromodichloromethane	75274	Y	100(c,d)	700.00	B2	26.92	7,000.00	27 (o)
Bromoform	75252	Y	100(c,d)	700.00	B2	443.04	15,000.00	350
Bromomethane (Methyl bromide)	74839	Y	-	49.00	D	-	100.00	25
Butyl benzyl phthalate	85687	-	100(e)	7,000.00	C	-	-	7,000
Butylate	2008415	-	-	1,750.00	-	-	2,000.00	1,800
Carbaryl	63252	-	-	3,500.00	-	-	1,000.00	3,500 (n)
Carbofuran	1563662	-	40(b)	175.00	-	-	50.00	180 (n)
Carbon tetrachloride	56235	Y	5(c)	24.50	B2	26.92	200.00	12
Carboxin	5234684	-	-	3,500.00	-	-	1,000.00	3,500 (n)
Chloral hydrate	302170	-	-	-	-	-	1,000.00	-
Chloramben	133904	-	-	525.00	-	-	3,000.00	530
Chlordane	57749	-	2(b)	2.10	B2	2.69	60.00	2.1
Chlorobenzene (Monochlorobenzene)	108907	Y	100(b)	700.00	-	-	2,000.00	350
Chlorodibromomethane	124481	Y	-	700.00	B2	41.67	7,000.00	42
Chloroform (Trichloromethane)	67663	Y	100(c,d)	350.00	B2	573.77	-	180
Chloromethane (Methyl chloride)	74873	Y	-	-	C	269.23	-	270

REMOVAL NUMERIC ACTION LEVELS FOR CONTAMINATED DRINKING WATER SITES
(April 8, 1991)

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Chemical ORGANICS	CAS#	Volatile (a)	MCL (ug/L)	DWEL (ug/L) (h)	WOE Class (i)	1E-4 RSC (ug/L) (j)	10-DAY HA (ug/L) (k)	Removal Action Level (ug/L)
Chlorophenol (2-)	95578	-	-	175.00	-	-	50.00	180 (n)
Chlorotoluene, o-	95498	Y(l)	-	700.00	-	-	2,000.00	350
Chlorotoluene, p-	106434	Y(l)	-	-	-	-	2,000.00	-
Chlorpyrifos	2921882	-	-	105.00	-	-	-	110
Chlorthalonsil	1897456	-	-	525.00	B2	1206.90	200.00	530 (n)
Chrysene	218019	-	0.2(e;s)	-	B2	-	-	-
Cyanazine	21725462	-	-	70.00	-	-	100.00	70
2,4-D(2,4-Dichlorophenoxyacetic acid)	94757	-	70(b)	350.00	-	-	300.00	350 (n)
Dacthal (DCPA)	1861321	-	-	17,500.00	-	-	80,000.00	18,000
Dalapon	75990	-	200(e)	1,050.00	-	-	3,000.00	1,100
DCE (cis-1,2-)(Dichloroethylene)	156592	Y(a)	70(b)	-	-	-	1,000.00	-
DCE(trans-1,2)(Dichloroethylene)	156605	Y	100(b)	700.00	-	-	2,000.00	350
Diazinon	333415	-	-	31.50	-	-	20.00	32 (n)
Dibenzo(a,h)anthracene	53703	-	0.3(e;s)	-	B2	-	-	-
Dibromochloromethane(Chlorodibromomethane)	124481	Y	100(c,d)	700.00	C	41.67	7,000.00	42 (o)

REMOVAL NUMERIC ACTION LEVELS FOR CONTAMINATED DRINKING WATER SITES
(April 8, 1991)

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Chemical ORGANICS	CAS#	Volatile (a)	MCL (ug/L)	DWEL (ug/L) (b)	WOE Class (i)	1E-4 RSC (ug/L) (j)	10-DAY HA (ug/L) (k)	Removal Action Level (ug/L)
Dibromochloropropane	96128	-	0.2(b)	-	-	-	50.00	-
Dibromomethane (Methylene bromide)	74953	Y	-	350.00	-	-	-	180
Dibutyl phthalate (di-n-Butyl phthalate)	84742	-	-	3,500.00	D	-	-	3,500
Dicamba	1918009	-	-	45.50	-	-	300.00	46
Dichloroacetic acid	79436	-	-	-	-	-	50,000.00	-
Dichlorobenzene(1,4)	106467	Y	75(c)	-	C	145.83	10,000.00	150
Dichlorobenzene(1,2-)	95501	Y	600(b)	3,150.00	-	-	9,000.00	1,600
Dichlorobenzene(1,3-)	541731	Y	600(b)	-	D	-	9,000.00	-
Dichlorodifluoromethane	75718	Y	-	7,000.00	-	-	40,000.00	3,500
Dichloroethane(1,1-)	75343	Y	-	3,500.00	C	-	-	1,800
Dichloroethane(1,2-)(Ethylene dichloride)	107062	Y	5(c)	-	B2	38.46	700.00	39
Dichloroethylene(1,1-)	75354	Y	7(c)	315.00	C	5.83	1,000.00	5.8 (o)
Dichloromethane(Methylene chloride)	75092	Y	5(e)	2,100.00	B2	466.67	2,000.00	470
Dichlorophenol(2,4-)	120832	-	-	105.00	-	-	30.00	110 (n)
Dichloropropane(1,2-)	78875	Y	5(b)	-	B2	51.47	90.00	52

REMOVAL NUMERIC ACTION LEVELS FOR CONTAMINATED DRINKING WATER SITES
(April 8, 1991)

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Chemical ORGANICS	CAS#	Volatile (a)	MCL (ug/L)	DWEL (ug/L) (h)	WOE Class (i)	1E-4 RSC (ug/L) (j)	10-DAY HA (ug/L) (k)	Removal Action Level (ug/L)
Dichloropropene(1,3-)(cis and trans)	542756	Y	-	10.50	B2	19.44	30.00	5.3
Dieldrin	60571	-	-	1.75	B2	0.22	0.50	0.22
Diethyl phthalate	84662	-	-	28,000.00	D	-	-	28,000
Diethylhexyl phthalate	117817	-	4(e)	-	-	-	-	-
Diisopropyl methyl phosphonate(DIMP)	1445756	-	-	2,800.00	D	-	8,000.00	2,800
Dimethrin	70382	-	-	-	-	-	10,000.00	-
Dimethyl phthalate	131113	-	-	35,000.00	D	-	-	35,000
Dinitrotoluene	25321146	-	-	-	B2	5.15	-	5.2
2,4-dinitrotoluene	121142	-	-	-	B2(m)	5.15	-	5.2
Dinoseb	88857	-	7(e)	35.00	D	-	300.00	35
Dioxane p-(1,4-)	123911	-	-	-	B2	318.18	400.00	320
Diphenamid	957517	-	-	1,050.00	-	-	300.00	1,100 (n)
Diquat	85007	-	20(e)	77.00	-	-	-	77
Disulfoton	298044	-	-	1.40	-	-	10.00	1.4
Diuron	330541	-	-	70.00	-	-	1,000.00	70

REMOVAL NUMERIC ACTION LEVELS FOR CONTAMINATED DRINKING WATER SITES
(April 8, 1991)

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Chemical ORGANICS	CAS#	Volatile (a)	MCL (ug/L)	DWEL (ug/L) (h)	WOE Class (i)	1E-4 RSC (ug/L) (j)	10-DAY HA (ug/L) (k)	Removal Action Level (ug/L)
Endothall	145733	-	100(e)	700.00	-	-	800.00	700
Endrin	72208	-	0.2(c);2(e)	10.50	D	-	20.00	11
Epichlorohydrin	106898	-	technq.(b)	70.00	B2	353.54	100.00	70
Ethylbenzene	100414	Y	700(b)	3,500.00	D	-	3,000.00	1,800 (n)
Ethylene dibromide (1,2-)(EDB)	106934	Y	0.05(b)	-	B2	0.04	8.00	0.04 (o)
Ethylene glycol	107211	-	-	70,000.00	-	-	6,000.00	70,000 (n)
Ethyl ether	60297	-	-	7,000.00	-	-	-	7,000
Ethylene thiourea (ETU)	96457	-	-	-	-	-	300.00	-
Fenamiphos	22224926	-	-	8.75	-	-	9.00	8.8
Fluometuron	2164172	-	-	455.00	-	-	2,000.00	460
Fluorene	86737	-	-	1,400.00	-	-	-	1,400
Fluorotrichloromethane	75694	-	-	-	-	-	7,000.00	-
Fonofos	944229	-	-	70.00	-	-	20.00	70 (n)
Formaldehyde	50000	-	-	7,000.00	B1	-	5,000.00	7,000 (n)
Freon 113(1,1,2-Trichloro-1,2,2-trifluoroethane)	76131	-	-	1.05E+06	-	-	-	1,100,000
Glyphosate	1071836	-	700(e)	3,500.00	D	-	20,000.00	3,500
Heptachlor	76448	-	0.4(b)	17.50	B2	0.78	10.00	0.78
Heptachlor epoxide	1024573	-	0.2(b)	0.45	B2	0.38	-	0.38
Hexachlorobenzene	118741	-	1(e)	28.00	B2	2.18	50.00	2.2
Hexachlorobutadiene	87683	-	-	70.00	C	44.87	300.00	45

REMOVAL NUMERIC ACTION LEVELS FOR CONTAMINATED DRINKING WATER SITES
(April 8, 1991)

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Chemical ORGANICS	CAS#	Volatile (a)	MCL (ug/L)	DWEL (ug/L) (h)	WOE Class (i)	1E-4 RSC (ug/L) (j)	10-DAY HA (ug/L) (k)	Removal Action Level (ug/L)
Hexachlorocyclopentadiene	77474	-	50(e)	245.00	D	-	-	250
Hexane(n-)	110543	-	-	21,000.00	-	-	4,000.00	21,000 (n)
Hexazinone	51235042	-	-	1,155.00	-	-	3,000.00	1,200
HMX(Octahydro-1,3,5,7-tetranitro- 1,3,5,7-tetrazocine)	2691410	-	-	1,750.00	D	-	5,000.00	1,800
Indeno(1,2,3-C,D)pyrene	193395	-	0.4(e;s)	-	B2	-	-	-
Isophorone	78591	-	-	7,000.00	C	853.66	15,000.00	850
Isopropylbenzene(Cumene)	88828	-	-	1,400.00	-	-	-	1,400
Lindane(Hexachlorocyclohexane, gamma)	58899	-	-	10.50	B2-C	2.69	1,000.00	2.7
Malathion	121755	-	-	700.00	-	-	-	700
Maleic hydrazide	123331	-	-	17,500.00	-	-	10,000.00	18,000 (n)
MCPA(4-Chloro-2-Methylphenoxy)- acetic acid	94746	-	-	17 50	-	-	100.00	18
Methomyl	16752775	-	-	875 00	-	-	300.00	880 (n)
Methoxychlor	72435	-	100(c);400(b)	175.00	D	-	2,000.00	180
Methyl ethyl ketone(2-Butanone)	78933	Y	-	1,750.00	D	-	8,000.00	880
Methyl parathion	298000	-	-	8 75	-	-	300.00	8.8

REMOVAL NUMERIC ACTION LEVELS FOR CONTAMINATED DRINKING WATER SITES
(April 8, 1991)

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Chemical ORGANICS	CAS#	Volatile (a)	MCL (ug/L)	DWEL (ug/L) (b)	WOE Class (i)	1E-4 RSC (ug/L) (j)	10-DAY HA (ug/L) (k)	Removal Action Level (ug/L)	
Methyl tert butyl ether	1634044	-	-	-	-	-	3,000.00	-	
Metolachlor	51218452	-	-	5,250.00	C	-	2,000.00	5,300	(n)
Metribuzin	21087649	-	-	875.00	-	-	5,000.00	880	
Monochloroacetic acid	79118	-	-	70.00	-	-	-	70	
Monochlorobenzene	108907	-	100(b)	700.00	-	-	2,000.00	700	
Naphthalene	91203	-	-	140.00	D	-	500.00	140	
Nitroguanidine	556887	-	-	3,500.00	D	-	-	3,500	
Oxyamyl	23135220	-	200(e)	875.00	-	-	200.00	880	(n)
Paraquat	1910425	-	-	157.50	C	-	100.00	160	(n)
Pentachloronitrobenzene(PCNB)	82688	-	-	105.00	C	13.50	-	14	
Pentachlorophenol	87865	-	200(b)	1,050.00	B2	29.17	300.00	29	(o)
Phenol	108952	-	-	21,000.00	-	-	6,000.00	21,000	(n)
Picloram	1918021	-	500(e)	2,450.00	-	-	20,000.00	2,500	
Polychlorinated biphenyls(PCBs)	1336363	-	0.5(b)	-	B2	0.45	-	0.45	(p)
Prometon	1610180	-	-	525.00	-	-	200.00	530	(n)
Pronamide(Kerb)	23950585	-	-	2,625.00	-	-	800.00	2,600	(n)
Propachlor	1918167	-	-	455.00	-	-	500.00	460	
Propazine	139402	-	-	700.00	-	-	1,000.00	700	
Propham	122429	-	-	700.00	-	-	5,000.00	700	
Pyrene	129000	-	-	1,050.00	D	-	-	1,100	

REMOVAL NUMERIC ACTION LEVELS FOR CONTAMINATED DRINKING WATER SITES
(April 8, 1991)

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Chemical ORGANICS	CAS#	Volatile (a)	MCL (ug/L)	DWEL (ug/L) (h)	WOE Class (i)	1E-4 RSC (ug/L) (j)	10-DAY HA (ug/L) (k)	Removal Action Level (ug/L)	
RDX (Hexahydro-1,3,5-trinitro- 1,3,5-triazine)	121824	-	-	105.00	C	31.82	100.00	32	
Simazine	122349	-	1(e)	70.00	C	29.00	500.00	29	
Styrene	100425	Y	5,100(b,f)	7,000.00	B2	-	2,000.00	3,500	(n)
T(2,4,5-)	93765	-	-	-	-	-	800.00	-	
TCDD(2,3,7,8-)(v)	1746016	-	5E-11(e)	-	B2	2.2E-05	1E-4	2.2E-05	
Tebuthiuron	34014181	-	-	2,450.00	-	-	3,000.00	2,500	
Terbacil	5902512	-	-	455.00	-	-	300.00	460	(n)
Terbufos	13071799	-	-	3.50	-	-	5.00	3.5	
Tetrachloroethane(1,1,1,2-)	630206	Y	-	1,050.00	C	134.62	2,000.00	130	
Tetrachloroethane(1,1,2,2-)	79345	Y	-	-	C	17.50	-	18	
Tetrachloroethylene(Perchloro- ethylene)	127184	Y	5(b)	350.00	B2	68.63	2,000.00	69	
Toluene	108883	Y	2,000(b)	7,000.00	D	-	3,000.00	3,500	(n)
Toxaphene(Octachlorocamphene)	8001352	-	5(c)	-	B2	3.18	40.00	3.2	(o)
TP(2,4,5-)(2(2,4,5- trichlorophenoxypropionic acid))	93721	-	10(c);50(b)	280.00	-	-	200.00	280	(n)
Trichloroacetaldehyde(Chloral)	75876	-	-	70.00	-	-	-	70	

REMOVAL NUMERIC ACTION LEVELS FOR CONTAMINATED DRINKING WATER SITES
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Chemical ORGANICS	CAS#	Volatile (a)	MCL (ug/L)	DWEL (ug/L) (b)	WOE Class (i)	1E-4 RSC (ug/L) (j)	10-DAY HA (ug/L) (k)	Removal Action Level (ug/L)
Trichloroacetic acid	76039	-	-	-	-	-	30,000.00	-
Trichlorobenzene(1,2,4-)	120821	-	9(e)	45.85	D	-	100.00	46
Trichlorobenzene(1,3,5-)	108703	-	-	-	-	-	600.00	-
Trichloroethane(1,1,1-)	71556	Y	200(c)	3,150.00	D	-	40,000.00	1,600
Trichloroethane(1,1,2-)	79005	Y	5(e)	140.00	C	61.40	400.00	61
Trichloroethylene(Trichloroethene)	79016	Y	5(c)	-	B2	318.18	-	320
Trichlorophenol(2,4,6-)	88062	-	-	-	B2	320.00	-	320
Trichloropropane(1,2,3-)	96184	Y	-	210.00	-	-	600.00	110
Trifluralin	1582098	-	-	262.50	C	454.55	30.00	260 (n)
Trinitroglycerol	55630	-	-	-	-	-	5.00	-
Trinitrotoluene(2,4,6-)	118967	-	-	17.50	C	120.00	20.00	18
Vinyl chloride	75014	Y	2(c)	-	A	1.84	3,000.00	1.8 (o)
Xylenes(mixed)	1330207	Y	10,000(b)	70,000	-	-	40,000.00	35,000

REMOVAL NUMERIC ACTION LEVELS FOR CONTAMINATED DRINKING WATER SITES
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Chemical INORGANICS	CAS#	Volatile (a)	MCL (ug/L)	DWEL (ug/L) (h)	WOE Class (i)	1E-4 RSC (ug/L) (j)	10-DAY HA (ug/L) (k)	Removal Action Level (ug/L)
Antimony	7440360	-	10;5(e,q)	14.00	-	-	15.00	14
Arsenic	7440382	-	50(e)	35.00	A	2.00	-	2 (p)
Asbestos	1332214	-	7,000,000(b) (fibers/liter)	-	A	-	-	-
Barium	7440393	-	1,000(c); 5,000(b)	1,750.00	-	-	5,000.00	1,800
Beryllium	7440417	-	1(e)	175.00	B2	0.81	30,000.00	0.81 (o)
Boron	7440428	-	-	3,150.00	-	-	2,000.00	3,200 (n)
Cadmium	7440439	-	10(c);5(b)	17.50	B1	-	40.00	18
Chromium III	16065831	-	-	35,000.00	-	-	1,000.00	35,000 (n)
Chromium VI	18540299	-	-	175.00	-	-	1,000.00	180
Copper	7440508	-	1,300(h)	1,298.50	D	-	-	1,300 (p)
Cyanide	57125	-	200(e)	700.00	D	-	200.00	700 (n)
Fluoride	16984488	-	4,000(c)	2,100.00	-	-	-	2,100 (p)
Lead	7439921	-	50(c);5(g)	-	B2	-	-	-
Manganese	7439965	-	-	3,500.00	D	-	-	3,500
Mercury	7439976	-	2(c)	10.50	-	-	-	11
Molybdenum	7439987	-	-	140.00	-	-	-	140
Nickel	7440020	-	100(e)	700.00	-	-	1,000.00	700
Nitrate	14797558	-	10,000(c)	-	-	-	10,000.00	-
Nitrite	14797650	-	1,000(b)	3,500.00	-	-	1,000.00	3,500 (n)

REMOVAL NUMERIC ACTION LEVELS FOR CONTAMINATED DRINKING WATER SITES
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Chemical INORGANICS	CAS#	Volatile (a)	MCL (ug/L)	DWEL (ug/L) (h)	WOE Class (i)	1E-4 RSC (ug/L) (j)	10-DAY HA (ug/L) (k)	Removal Action Level (ug/L)
Nitrate + Nitrite		-	10,000(b)	-	-	-	-	-
Selenium	7782492	-	10(c), 50(b)	105.00	-	-	-	110
Silver	7440224	-	50(b)	105.00	D	-	200.00	110
Strontium	7440246	-	-	-	-	-	25,000.00	-
Sulfate (volumetric std. in water)	7757826	-	4E+5, 5E+5(e,r)	-	-	-	-	-
Thallium	7440280	-	2;1(e,q)	2.45	-	-	7.00	2.5
Vanadium	7440622	-	-	245.00	-	-	-	250
White Phosphorus	772314	-	-	0.70	D	-	-	0.70
Zinc	7440666	-	-	7,000.00	D	-	-	7,000

(a) All Volatile Organic Compounds (VOCs) were determined using 40 CFR Part 264, Appendix IX with the following exceptions

1 The following two chemicals were classified as VOCs based on the Superfund Contract Laboratory Program Statement of Work, October 1986 (Exhibit C)

- 1,1-Dichloroethane
- 1,1-Dichloropropene (cis and trans)

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2. The following six chemicals were classified as VOCs based on OSW's Test Methods for Evaluating Solid Waste. Volume 1B, SW-846, 3rd ed , November 1986.

- Bromobenzene
- Bromochloromethane
- Chloroacetaldehyde (2-)
- Chlorotoluene, o-
- Chlorotoluene, p-
- Trichloropropane (1,1,1-)

3 Trans-1,2-DCE is listed as a volatile organic compound (VOC) in 40 CFR Part 264, Appendix IX. For purposes of this table, cis-1,2-DCE is also considered volatile because it has a Henry's Law Constant of 1.5×10^{-2} atm-m³/mole

(b) Proposed MCL, Proposed Rule, Federal Register Vol 54, No. 97, May 22, 1989, 22062-22160

(c) Final MCL; 40 CFR Part 141 - National Primary Drinking Water Regulations. 526-533, 585-587

(d) The value of 100 ug/liter is for total trihalomethanes (i.e., sum of chloroform, bromodichloromethane, dibromochloromethane and bromoform).

(e) Proposed MCL, Proposed Rule, Federal Register Vol 55, No 143, July 25, 1990, 30370-30448.

(f) EPA proposed MCLs of 100 ug/L based on a Group C carcinogen classification and 5 ug/L based on a B2 classification.

(g) Proposed MCL, Proposed Rule, Federal Register Vol 53, No 160, 31515-31578, Thursday, August 18, 1988.

(h) DWEL - Drinking Water Equivalent Level based on the reference dose from IRIS or HEAST Assumes 70 kg body weight and 2 L/day water intake.

(i) EPA's weight-of-evidence classification for carcinogenicity.

(j) RSC (1×10^{-4}) - Risk-specific concentration based on the slope factor from IRIS or HEAST and a unit of 1×10^{-4} . Assumes 70 kg body weight and 2 L/day water intake.

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- (l) Although these specific compounds were not designated as volatile, the general group (e.g., chloroacetaldehyde, chlorotoluene, trichloropropane) was designated as volatile in SW-846.
- (m) These values were taken from EPA's Health Effects Assessment Summary Tables (HEAST) (Fourth Quarter, FY 1990).
- (n) Removal Action Level, when based on the DWEL, is an interim value. OERR is examining whether it would be appropriate to use the lower 10-day HA (50 percent of 10-day HA for volatiles) as the action level. Until that time, if contaminant levels exceed action levels shown in the table, removal action may be taken. If contaminant levels exceed 10-day HA, but not the DWEL, consult OERR.
- (o) Removal Action Level is equal to or less than the MCL. Removal action may be initiated immediately if levels exceed the 10-day HA (50 percent of the 10-day HA for volatiles). In cases where contaminant levels exceed Removal Action Levels based on DWEL or 1E-4 RSC, but not the 10-day HA, consult OERR.
- (p) Removal Action Level is equal to or less than the final MCL, but no 10-day HA is available
- (q) EPA has proposed alternative MCLs for antimony and thallium. See 55 FR 30409
- (r) EPA has proposed alternative MCLs (to equal the two alternative proposed MCLGs, i.e., 400 mg/L and 500 mg/L) for sulfate. See 55 FR 30420
- (s) EPA has proposed an option for setting the MCL equal to the practical quantitation levels (PQLs) for each of these PAHs in addition to benzo(a)pyrene. Under this option, individual MCLGs equal to zero would be set for each of these PAHs. See 55 FR 30409
- (t) Pending review by IRIS or addition to IRIS. These values were taken from EPA's Health Effects Assessment Summary Tables (HEAST) (Fourth quarter, FY 1990)
- (u) Currently on IRIS, but under review
- (v) 2,3,7,8-TCDD is a member of the Dioxin group

Appendices

APPENDIX 1

Toxicology

Risk assessment and safety determination are essential to ensure that field operations are as risk-free and safe as possible. Risk is defined as the probability that a certain substance will induce injurious effects in exposed human populations. Safety ($1 - \text{Risk} = \text{Safety}$) is the probability that injurious effects will not be induced under certain consistent exposure conditions. By evaluating the relative toxicities of harmful substances and applying the principles of toxicology, field personnel can determine the degree of hazard associated with the chemicals at a site and respond in a manner appropriate to the level of risk.

Toxicology is the study of the harmful effects of chemicals on living organisms. Toxicologists determine the risk associated from exposure to a specific compound by performing a series of detailed scientific experiments to define the relationship between various doses of the compound administered and the range of observable adverse effects. This dose vs. response relationship is the fundamental concept in the discipline of toxicology.

NOTE: Toxicological exposure constants, such as the LD50 referred to on the following pages, are concentrations which represent a given level of risk of injury to the exposed population. For example, the LD50 implies a risk of 50 percent lethality to the population. The risks associated with all exposure constants, including TLV, PEL, and IDLH, involve a time frame for exposure. Generally, LD50 and IDLH refer to short term or acute exposure situations. Exposure constants involving "allowable" exposure limits such as TLV or PEL are determined based on longer term, or chronic exposures. The difference between acute and chronic exposure is critical in this discussion of toxicology. While neither exposure situation can be considered less severe than the other, acute health threats require more "real-time" response capability and are thus the focus of this discussion. Concentrations of contaminants which represent an emergency health threat through daily or chronic exposure are the focus of the chapter on "Emergency Removal Guidelines." Any questions concerning acute vs. chronic exposures, and emergency health threats associated with each, should be referred to an EPA toxicologist.

Dose Vs. Response Relationship

The dose vs. response relationship states that the biological response observed following exposure to a chemical is a function of the administered dosage. The relationship implies that all compounds have the potential to be toxic. The dose of the compound administered determines the severity of the effect observed.

RELATIVE TOXICITY

Among chemicals, there is a wide range of doses required to elicit specific levels of toxic responses. Some chemicals are toxic in doses as low as microgram quantities and are thus considered extremely

toxic, while other chemicals may require a dose of several grams to elicit toxic reactions. Through this range of doses and associated effects, toxicologists employ the dose vs. response relationship to determine the risk associated with exposure to a known concentration of a chemical. The following table gives some examples of relative toxicity.

TOXICANT	LD50 (mg/kg)	TOXICITY RELATIVE TO ETHANOL (times more toxic)
Ethanol	10,000	-
Sodium chloride	4,000	2.5
Phenobarbital	150	66.6
Nicotine	1.0	10,000.0
Dioxin (TCDD)	0.001	10,000,000.0
Botulinum toxin	0.000001	10,000,000,000.0

From this table, it is possible to interpret the degree of risk associated with exposure to any one of these substances, relative to the toxicity of ethanol. Similarly, these compounds can be compared to each other or to any other compound. This concept of relative toxicity can be very useful to the field investigator, particularly when dealing with unknown concentrations of a chemical.

DISTRIBUTION OF DOSE VS. RESPONSE RESULTS

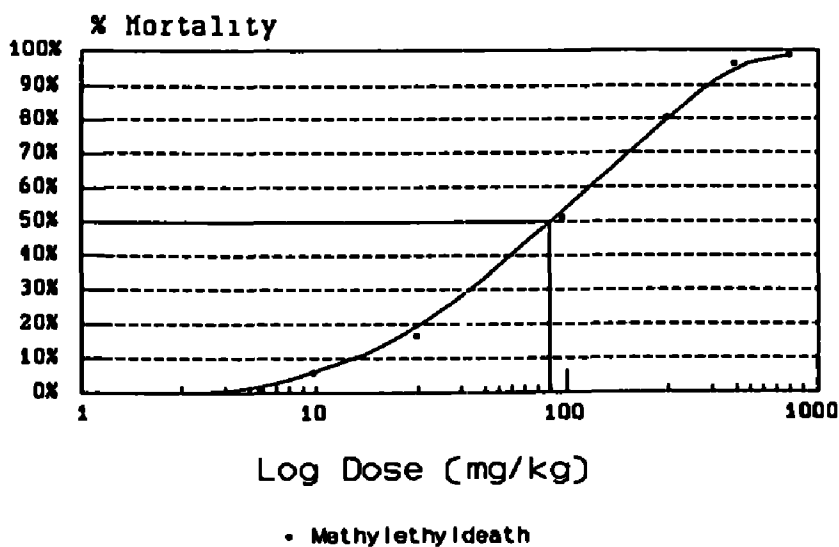
Another practical benefit of the dose vs. response relationship is that the effects observed during a particular toxicological investigation can be predicted. The responses of the exposed population in an experiment are distributed in such a way as to be considered "normal," or predictable. Normal distribution of effects implies that there will be a biological variation in toxicological responses in a study.

BIOLOGICAL VARIATION

Biological variation is the term used for the occurrence of differing susceptibilities in a population exposed to a toxic chemical. Factors that contribute to biological variation include sex, age, nutritional status, weight, metabolic type, and state of health, to mention a few. Biological variation is accounted for in all models of toxicological testing.

The following graph depicts the effects hypothetically observed in a population exposed to a range of doses of the fictional chemical, methylethyldeath. Results of the experiment have been fit into the normal statistical distribution of the dose vs. response relationship. Note that the majority of deaths occurred within proximity of the Lethal Dose 50 (LD50), the dose required to kill 50 percent of the exposed population. The Lowest Observed Adverse Effect Level (LOAEL) is the lowest dose administered that resulted in the death of one member of the exposed population. The No Observed Adverse Effect Level (NOAEL) is the highest dose administered that did not result in the death of a member of the population.

LD50 & Dose Response



Classification of Toxicants

Toxic agents may be classified in many ways. Agents can be classified based upon the target organ of toxicity, the intended use of the compound, the physical state of the compound, the DOT labeling requirements, the chemical type, or the poisoning potential of the compound. Frequently, a chemical is classified under numerous categories, as the following table depicts.

AGENT NAME	DOT CLASS	PHYSICAL STATE	USEAGE	CHEMI-CAL FORM	TARGET ORGAN
Aldrin	Poison	Solid	Pesticide	Organo-chlorine	CNS, Liver
Benzene	Flammable Liquid	Liquid Dye Base	Solvent	Aromatic	Blood, skin
CCL4	Nonflam. Liquid	Liquid	Propellant Degreaser	Chlor. Hydro-carbon	CNS, Lung, Kidney
Mercury	Poison	Solid/Liquid	Consumer Products	Heavy Metal	CNS, Kidney, Fetuses
Asbestos	ORM*	Solid	Insulator	Fiber	Lung, GI Tract
Toluene	Flammable	Liquid	Solvent	Aromatic	CNS, Liver

* ORM refers to Other Regulated Materials, which is essentially a miscellaneous DOT class

When checking the classification of a toxin, refer to multiple sources, as no one text completely characterizes a compound. For additional sources of information, refer to page 7.

Routes of Exposure

The principal routes of human exposure to environmental toxins are inhalation, ingestion, and absorption via an environmental medium such as air, soil, or water. To a lesser degree, injection can also be considered a route of exposure. In order for an agent to produce injurious effects in humans, the agent, or its metabolic products, must reach critical organs within the body at sufficient concentrations for a given period of time. To achieve this, the agent must be transported through its environmental medium or matrix without undergoing any type of physical or chemical change which would render the compound inactive.

It is imperative in an emergency health threat determination that the routes of exposure be firmly established. Without a verified exposure route, a chemical is said to be only potentially hazardous.

INHALATION

Inhalation, exposure through the respiratory system, is the most common route of exposure of humans to hazardous materials. The components of the respiratory system include the nose, pharynx, larynx, trachea, bronchi, and lungs.

The lungs are the critical organs for the transfer of gases in the body. Normal lungs function to exchange metabolic wastes such as carbon dioxide from the bloodstream for oxygen and nitrogen from the atmosphere. Once oxygen is inside the body, it is transported by a blood protein called hemoglobin. The nose, sinuses, pharynx, larynx, trachea, and bronchi all serve as specialized ducts for the passage of air during inhalation and exhalation. The trachea and bronchi are especially important in the removal of particulate matter inhaled with air. Both the trachea and bronchi are lined with hair-like projections termed cilia. Cilia act in a wave-like manner, forcing deposited particles upward towards the esophagus, where they are swallowed. Cigarette smoke greatly impairs the ability of cilia to remove contaminants from the lung. For this reason, smoking can be an aggravating factor in respiratory injury associated with exposure to air-borne toxicants.

The lungs are the only major internal organs which come into direct contact with the external environment, and are thus particularly susceptible to the effects of toxicant exposure. The lungs are affected by the inhalation of toxic gases, vapors, and/or particulate matter. The ability of a compound to produce adverse effects depends upon:

- The physical and chemical nature of the inhaled substance.
- The health state of the exposed individual.
- The metabolic processes that may affect the chemical.
- The ability of the chemical to be transported to organs in concentrations sufficient to elicit toxic reactions.

The uptake of gases and vapors occurs through all areas of the respiratory system and can result in local or systemic effects. Absorption of a gas or vapor by the body depends upon the solubility of the compound. Generally, lipid (oil/fat) soluble substances show greater absorption rates.

Chemical respiratory toxicants cause injury due to their chemical properties and are classified according to their effect on the respiratory system. Reactions can be local or systemic. The classes of respiratory toxicants are:

- **Simple Asphyxiants.** These substances are physiologically inert gases that, at high concentrations, displace oxygen from the air, thus preventing oxygen from being taken into the lungs during inhalation. Examples of simple asphyxiants include nitrogen, helium, argon, and methane.
- **Chemical Asphyxiants.** These compounds bind with hemoglobin in place of oxygen, preventing oxygen from being absorbed by the body during inhalation. Examples of chemical asphyxiants include carbon monoxide and cyanide.
- **Irritants.** These are substances that irritate the passageways of the respiratory tract and cause either a fluid buildup known as edema or an infection such as pneumonia. Irritants include ammonia, hydrogen chloride, chlorine, and hydrogen fluoride, or any corrosive substance capable of being inhaled.

- **Necrosis Producers.** Necrosis is the process of cell death. Necrosis producers cause cell death and the accompanying edema. Examples of substances that induce necrosis are ozone and nitrogen dioxide.
- **Fibrosis Producers.** Fibrosis is a body response in which scar tissue is formed following exposure to by a toxic substance. Fibrosis in the lungs results in decreased surface area for gas exchange, causing reduced oxygen delivery to the body. A good example of fibrosis is the scarring that accompanies severe burns due to inhalation of superheated gases; strong acids and bases; or silicates, asbestos and beryllium.
- **Allergens.** These substances induce an allergic response in the exposed person. Typically, the allergic response is characterized by constriction of the respiratory passages and symptoms that mimic those of asthma. Examples of allergens include sulphur dioxide and isocyanates.
- **Carcinogens.** These compounds can cause the uncontrolled proliferation of cells within the lungs or in remote body locations of the exposed person. Compounds with proven abilities to cause lung cancer in humans include cigarette smoke, coke oven emissions, and arsenic.
- **Systemic Toxicants.** Compounds capable of entering the body through inhalation and causing toxic injury at locations other than the lungs are called systemic toxicants. Examples include many of the organic solvents such as carbon tetrachloride and trichlorethane, which affect the liver; the metals mercury and lead, which affect the central nervous system; and benzene, which affects bone marrow.

The toxic effects of particulates depend not only on the physical and chemical properties of the particles in question, but also on the particle size. Larger particles settle in the upper portions of the system to be removed by ciliary action. The smaller the particle, however, the greater ability it has to travel deep into the small spaces of the lung, thus potentially causing greater harm. Once small particles are deposited in the lower portions of the lungs, their fate includes:

- Absorption into the bloodstream (particles of greater than 5.0 micrometers do not normally diffuse through cell walls).
- Removal through phagocytosis, a process in which immune cells attempt to remove the particles by incorporating them into their cell structure.
- Cell toxicity resulting in fibrotic (scar-like) tissue formation and decreased gas exchange area.

Certain types of particulates, such as asbestos and silica, can not be effectively eliminated by the body. Incomplete removal results in irritation and death of the cell, causing further immune response. Irritation may be severe enough to cause fibrosis of portions of the lung or a cancerous growth.

An important aspect of asphyxia and respiratory toxicants is the effect of oxygen-deficient atmospheres. Normal oxygen content in air ranges from 19.5 percent to 21 percent. Some atmospheres, such as those generated during a fire or hazardous material release, contain less oxygen. For this reason, it is imperative that the oxygen content of any atmosphere be determined before the selection of respiratory protective equipment. Confined space entries represent an especially hazardous exposure situation. Particular attention should be paid to the presence of combustible or explosive atmospheres, as volatile organic vapors can collect rapidly within a confined space.

EFFECTS OF OXYGEN CONCENTRATION ON HUMANS

PERCENT OXYGEN	EFFECTS
>21	Explosive atmosphere, keep out!
21-16	Nothing abnormal
16-12	Loss of peripheral vision Rapid breathing and heart rate Impaired coordination
12-10	Poor judgement and coordination Excessive fatigue Permanent heart damage Sparse breathing
10-6	Nausea Loss of movement Unconsciousness followed by death
Less than 6	Spasmodic breathing Convulsive movements Death

ABSORPTION

Absorption of toxic agents as a route of exposure refers to the passage of toxicants through either the skin, eyes, or other openings in the body. Absorption is the second most common route of exposure to hazardous materials, and frequency occurs through direct contact between the chemical and the skin of the exposed person.

The skin serves as a barrier to prevent most foreign substances from entering the body. It also functions to preserve the components of the body. The skin has three layers: the epidermis, the outermost layer, is composed of mostly dead cells that adhere to the living tissue underneath and are responsible for the skin's effectiveness as a barrier; the dermis, a layer of loose connective tissue, contains the blood

vessels closest to the skin surface and is actively involved in wound repair; the hypodermis, the innermost layer, contains connective and adipose (fat) tissue.

The absorption of chemicals through the skin is called percutaneous absorption. It depends upon:

- The integrity of the skin.
- The vehicle through which the toxicant is administered.
- The type of toxicant.

Factors that facilitate percutaneous absorption include:

- Reduced integrity of the outer skin layer.
- Increased hydration of the skin.
- Increased temperature of the skin.
- Altered skin pH.
- Increased blood flow to the skin.
- Increased concentration of the toxicant.
- Decreased particle size of the toxicant.
- Electrically induced movement of the toxicant.
- The addition of agents that react with the skin surface.

Toxins may produce the following topical skin reactions:

- **Irritation.** Toxicants that are irritants cause an inflammatory skin reaction called dermatitis that is characterized by itching, redness and skin lesions in the exposed area. Examples of chemical irritants include acids, bases, phenols, solvents, metals and pesticides.
- **Corrosion.** Corrosive chemicals cause the disintegration and irreversible alteration of the skin at the site of contact. Most severe corrosive reactions are often designated as chemical burns. Alkaline substances are considered more damaging than acidic substances, due to latent effects of the chemical. Examples of corrosives include acids, bases, flammable solids and peroxides.

- **Allergic Sensitization.** Sensitizers affect the immune system of the exposed person, causing a delayed hypersensitivity. There may be no obvious skin reaction during the initial exposure but toxic manifestations are exhibited after subsequent exposures. Examples of sensitizers include peroxides, metals, and solvents.
- **Photosensitization.** Photosensitizers cause increased sensitivity of the skin to ultraviolet light. Physiological changes which are observed include irritation and redness, sunburn, darkening pigmentation, and alteration in normal skin cell proliferation which can lead to skin cancer. Examples of photosensitizers include polycyclic aromatic hydrocarbons.

Absorption of a toxicant through the skin barrier may lead to systemic effects at locations away from the site of exposure, as well as to the topical reactions described above. Systemic effects include liver dysfunction, cancer, brain damage or cardiac arrest, as well as others. Compounds producing systemic reactions include pesticides and solvents.

The same chemicals that can damage the skin can damage the eye. The eyes are actually more sensitive to exposure than the skin due to their high fluid content and lack of a barrier. The primary concerns with exposure to ocular toxicants are:

- **Local effects** - direct effects caused by the application of a chemical to the cornea.
- **Systemic effects** - effects to other organs or organ systems in the body, caused by the application of a chemical to the eye.
- **Ocular side effects** - effects which occur in the eye from exposure to toxicants through other routes of exposure such as inhalation and ingestion.

The types of chemicals noted for their ocular toxicity are acids, bases, organic solvents, detergents, and lacrimators. Acids affect the eye by reacting with protein in the tissues and by dehydrating the tissues. Treatment involves flushing the eye with large amounts of

water. Generally, the greater the concentration of the acid, the greater ability it has to induce harm.

Alkaline substances (bases) act on the eye in a very different manner from acidic ones. Bases produce the same initial effects as acids, due to the pH of the base and the heat produced during reaction. However, contrary to acid burns, the effects observed immediately after exposure to an alkaline substance are not a good index of the total effects of exposure because latent effects may continue to occur up to two weeks after exposure. An example of the effect of an alkaline substance on the eye is exposure to sodium hydroxide (NaOH); irrigation of the eye with a concentrated solution of NaOH for more than three minutes could cause catastrophic changes in the cornea leading to complete opacification (clouding) within a week to ten days after exposure. Other alkaline substances that are potent ocular toxicants include potassium hydroxide and ammonia.

Organic solvents react with the proteins and fats in the eye, causing severe pain. Damage is usually not extensive and can be reversed. In the case of heated solvents, there is the threat of burning, resulting in damage that is often severe and unpredictable. Examples of organic solvents include ethanol, toluene, and acetone.

Detergents react to lower the surface tension of the liquids in the eye, causing pronounced irritation followed by extensive tearing. Concentrated doses can cause severe burns with permanent fogging of the cornea. Examples of detergents include household cleaning agents, emulsifying agents, wetting agents, and antifoaming agents.

Lacrimators are chemical compounds or mixtures which have the ability to induce instant tearing at very low concentrations without reacting with tissues of the eye. High concentrations can cause tissue damage. Examples include mace (tear gas) and smog.

INGESTION

The ingestion of hazardous substances is the third most frequent route of exposure in humans. Ingestion of hazardous substances occurs through the consumption of:

- Contaminated waters.
- Fish from contaminated waters.

- Contaminated plants and animals.
- Incidental ingestion of soils and dusts.

Exposure to toxicants through ingestion is of most concern with young children, who can ingest large amounts of soil every day in the course of normal play activities. Young children are also particularly susceptible to the adverse effects of some contaminants (lead, for example) that may be ingested.

Once a toxicant is ingested, it enters the gastrointestinal (GI) tract. The GI tract is essentially a long tube beginning at the lips and ending at the anus, and includes the mouth, esophagus, stomach, and the small and large intestine. Throughout the course of the GI tract, ingested toxicants can be absorbed into the bloodstream. Absorption primarily occurs in three main areas of the GI tract: the stomach, the small intestine, and the large intestine.

Humans have developed sophisticated mechanisms in the liver for the detoxification of foreign substances. These mechanisms include enzymatic reactions and excretion to the bile and urine. Liver functions can, however, convert a substance into an even more toxic form. Further, detoxification mechanisms are easily overridden, particularly in cases of exposure to multiple agents or to large doses of a single agent.

Exposure to toxic chemicals through the GI tract can result in both local and systemic effects. Local effects include the reaction of the chemical with the exposed internal surface of the GI tract, as in the case of acid ingestion. Systemic effects result from absorption of the chemical into the bloodstream and transport to critical organs. Serious systemic effects can include liver damage, kidney damage, and cancer.

INJECTION

Injection refers to the combination of toxic exposure with a physical trauma, such as a laceration. Injections should be considered very dangerous, since the toxicant is being directly injected into the bloodstream of the exposed person. Proper site safety practices (e.g., the buddy system) can be effective in preventing injection exposures.

Exposure to Chemical Mixtures

Emergency health threat determinations involving mixtures are complex and difficult to make because little is known about the toxic properties of a mixture of compounds. Toxins in a mixture can interact with each other and with the body to produce any one of the four following effects:

- **Additive Effects** (e.g., $2+3+4=9$). These effects are produced when the combined effect of the chemicals is equal to the sum of the individual effects of all the chemicals in the mixture. Examples of a mixture that produces additive effects are organophosphate pesticides such as parathion and malathion.
- **Synergistic Effects** (e.g., $2+3+4=25$). Effects that are greater than the sum of the component chemicals in the mixture are said to be synergistic effects. An example of a synergistic effect is the combined effects of cigarette smoke and asbestos; smokers show a strikingly higher cancer rate from asbestos exposure than do nonsmokers.
- **Potentiation Effects** (e.g., $0+2=10$). One of the chemicals in a mixture may not itself be particularly toxic, but it reacts to increase the toxicity of another chemical in the mixture, producing potentiation effects. An example of a potentiation effect is the increased toxicity observed with carbon tetrachloride (CCl_4) exposure accompanied by isopropanol. Isopropanol is considered to be relatively nontoxic when administered by itself. However, when administered with CCl_4 , it exacerbates the toxicity of CCl_4 by preventing detoxification mechanisms in the liver from reacting with CCl_4 molecules.
- **Antagonistic Effects** (e.g., $4+(-4)=0$). A mixture in which one or more of the chemicals present inhibits the toxicity of other compounds in the mixture is said to produce antagonistic effects. Antagonistic actions between chemicals serve as the basis for antidotal therapy.

NOTE: Exposure criteria for chemical mixtures do not exist and other information can be very difficult to gather. In situations involving exposure to a mixture of chemicals, it is advisable to assemble a team of experts, including chemists and toxicologists, to characterize the situation most completely.

Determination of Toxic Potential

Regulatory guidelines have been established by federal agencies in an attempt to define acceptable concentrations of toxicants that humans can be exposed to without experiencing adverse health effects. These guidelines are derived from the results of dose vs. response studies, which are extrapolated to fit human exposure situations. The extrapolation process involves the incorporation of a series of safety factors to ensure that the regulated doses are extremely conservative estimates of likely harm.

In addition to LD50, the toxic potential of a compound can be expressed by the following acronyms:

- **TLV (Threshold Limit Value).** The threshold limit value refers to an allowable atmospheric concentration of a compound. The value is designated as the level of exposure at which the probability of the occurrence of adverse health effects is deemed negligible. TLVs are determined by the American Council of Governmental Industrial Hygienists (ACGIH).
- **TLV-TWA (Threshold Limit Value-Time Weighted Average).** This is the average concentration of a substance to which a worker can be exposed for eight hours a day, 40 hours a week, 50 weeks a year for the lifetime of the worker without experiencing any adverse health effects.
- **TLV-STEL (Threshold Limit Value-Short Term Exposure Limit).** This is the concentration of a substance to which a worker can be exposed for a short period of time, usually less than 15 minutes, without experiencing any adverse health effects.

- **TLV-C (Threshold Limit Value-Ceiling).** This is a ceiling concentration to which the worker should never be exposed, even briefly.
- **PEL (Permissible Exposure Limit).** For many substances this value may be similar to the TLV-TWA and is in some cases identical. PELs are established by NIOSH and adapted by OSHA to protect workers who may be exposed to hazardous materials through their work functions. A PEL for a substance is the average concentration in the atmosphere at or below which workers may be exposed for eight hours a day, 40 hours a week, and 50 weeks a year for the lifetime of the worker without experiencing any adverse health effects.
- **IDLH (Immediately Dangerous to Life and Health).** This is an airborne concentration of a hazardous substance to which an individual may be exposed for one half hour, in the occurrence of a failure of respiratory protective equipment. These values are assigned by NIOSH to aid in the selection of respiratory protection; they are not meant to be an acceptable exposure limit. No worker should enter an IDLH atmosphere without proper respiratory protection.
- **MCL (Maximum Contaminant Level).** MCLs are mandated by the Safe Drinking Water Act (SWDA) of 1972 and are established by the National Academy of Sciences and EPA to regulate contaminants in public drinking water supplies. MCL values are changed regularly to reflect improvements in treatment technologies.

Frequently, one chemical may have numerous exposure criteria. The field investigator should select the criteria that apply to perform a particular field operation safely. The most conservative exposure value (e.g., the lowest value) should be chosen to ensure site safety even further.

The exposure criteria for carcinogenic substances are not as easily ascertained as those for noncarcinogenic substances. Essentially, carcinogens are believed to be capable of producing uncontrolled cell proliferation at doses below the detection capability of analytical instrumentation. Field operations involving carcinogens and other highly toxic compounds should assume a zero exposure level. Zero exposure levels are the only accepted safety practices for dealing with carcinogenic substances. For further information regarding carcinogens, it is advisable to consult an EPA toxicologist.

Emergency Health Threat Determination

The critical process of emergency health threat determination involves the characterization of the hazard, the verification of a route of exposure, the establishment of the toxic potential of the compound through the verified route of exposure, and the selection of applicable regulatory criteria. Although details of the process vary from site to site, situation to situation, the process remains the same.

Emergency health threat determination represents an essential component of any field operation. To prevent unnecessary risk taking, field personnel should review all data about the site and evaluate all possible considerations regarding the presence, location, storage, use, and transport of hazardous materials. Thorough training and the proper use of reference guides, field personnel can become effective risk evaluators, rather than risk takers.

APPENDIX 2

Environmental Media

Air, soil, and water are the environmental media through which exposure to toxic substances occurs. Awareness of the properties of each medium aids in evaluating routes of exposure and in determining sample locations. In making these determinations, it is also important to consider the impact the prevailing weather conditions in an area have on the air, soil, and water onsite.

Air

Air contaminants may pose an inhalation, ingestion, and direct contact threat to the public over very large areas downwind of the site. Sudden, unexpected shifts in wind direction are of particular concern because they can cause exposure to site workers and the public in areas previously considered to be safe. Wind direction and speed are the primary factors governing transport of air contaminants - both gases and particulates. Winds arise from horizontal pressure gradients in the atmosphere and can change rapidly in direction and speed in the vicinity of fronts. Some locations, such as mountainous areas and areas along large lakes, experience diurnal fluctuations in wind direction caused by daily temperature changes. These daily changes also enhance contaminant dispersion.

Air releases include volatilization from contaminated soils, from covered landfills (with and without internal gas generation), from spills and leaks from containment facilities, and from lagoons. Contaminant releases into the atmosphere may also consist of fugitive dusts resulting from wind erosion of contaminated soils and from traffic over contaminated, unpaved roadways. When a stable suspension of dust or other solid particles or of liquid droplets in air occurs, it is called an aerosol.

Temperature and atmospheric pressure influence the rate of air releases. With increasing temperature, the rate of volatilization of compounds tends to increase. Volatiles may be released from liquids even on cold days because solar radiation can increase the temperature of a liquid more rapidly than the temperature of air. Temperature also governs atmospheric stability, which is the degree to which the atmosphere tends to dampen out vertical motion. In an unstable atmosphere, the temperature decreases rapidly with increasing elevation, resulting in turbulence (wind). In a stable atmosphere, the temperature may remain constant throughout the column of air or, in the case of an inversion, even increase with elevation. Stable conditions typically occur in late afternoon through early morning under clear skies with light winds. Atmospheric pressure tends to affect the migration of landfill gases, causing a landfill to offgas at a higher rate following low atmospheric pressures. When the atmospheric pressure is high, the landfill may cease offgassing entirely.

Humidity is not a factor in the generation and transport of air contaminants. It can influence the hazards of a release, however. In the case of a release of hydrogen chloride gas, for example, the hazards posed by hydrochloric acid should be considered, especially on an extremely humid day.

DISPERSION MECHANISMS

The relative directional frequencies of wind over a site determine the primary direction of movement of airborne contaminants - both gases and particulates. Wind speed and direction are influenced not only by meteorological conditions, but also by the topography of an area. Even tall buildings and other large structures can influence wind speed and direction in small, localized areas.

Atmospheric stability and wind speeds determine the offsite areas to be affected by ambient concentrations of gases. In general, high stability and low wind speeds result in higher atmospheric concentrations of contaminant gases close to the site. High stability and moderate wind speeds result in moderate concentrations over a large area downwind of the site. Low stability or high wind speeds cause greater dispersion and dilution of contaminants, resulting in lower concentrations over larger areas.

Furthermore, wind speed is a critical factor in generating airborne contaminated particulate material. At higher speeds, the turbulence of the air and its forward motion lift particles into the windstream for transport. Under windy conditions, transport of contaminated particulates, particularly metals, dioxin, and PCBs, can pose significant health threats downwind of the site. Transport of contaminated particulates is generally not a concern, however, when the soil is wet because of the increased threshold wind speed required to make the particles airborne.

Ambient concentrations of particulate contaminants are controlled by particle size distribution as well as by windspeed and stability. Large particles settle out rapidly, resulting in decreased atmospheric concentrations with distance from the site. Smaller particles remain airborne longer and approximate the behavior of gaseous contaminants.

INTERMEDIA TRANSFER MECHANISMS

Settleout and rainout are mechanisms of contaminant transfer from the atmosphere to surface soils and waters. Contaminants dissolved in rainwater may percolate to ground water, run off or fall directly into surface waters, and adsorb to uncontaminated soils. Contaminants can enter the food chain through direct intake of the atmosphere by plants and animals and through intake of secondarily contaminated soils and water.

Soils

Soil represents a medium of direct contact and ingestion threat and may be the main source of contaminants released into other media (air, water). Direct soil contamination occurs from leaks or spills from containers and containment facilities. The spilled liquids and solids may be transported through soil or may be partially or fully retained within the soil to provide a continuous environmental and/or public health threat. At the site of a release and along the release pathway, discolored soils, stressed or dead vegetation, and uncharacteristic odors may be preliminary indicators of soil contamination.

DISPERSION MECHANISMS

To predict the fate and transport of a hazardous substance released onto the soil surface, the properties of both the substance spilled and the soil must be considered. The mobility of a material in soil is influenced by many factors: soil type, temperature, porosity, and biological and chemical activity, along with the water solubility, vapor pressure, and physical state of the substance released. Liquid movement is the most significant dispersion mechanism in soils. Liquid contaminants percolate directly into soils, and contaminants of lower viscosity and/or higher density than water can have percolation rates much greater than that of water. Dry, soluble contaminants dissolved in precipitation, run-on, or irrigation water can also migrate through percolation into the soil and through runoff. The rate of movement of solid contaminants through soil is a function of net ground water recharge rates and of contaminant solubility.

To determine in detail how a release may behave, it is necessary to establish the predominant nature of the soils onsite. It is also important to establish whether such underground features as clay layers, sink holes, and fractures are present. These and other subsurface features can greatly facilitate or retard the spread of contamination.

INTERMEDIA TRANSFER MECHANISMS

Releases which occur on soils with low runoff potential, such as well-drained sands or gravel, have a high infiltration rate. Spills on these types of soils will migrate offsite rapidly and may present a threat to ground water. Loamy and clay soils with a moderate to high runoff potential provide a low infiltration rate and a surface conducive to overland flow. Releases occurring on these types of soils may create a hazard at some distance to the site as the spilled substance travels overland to surface waterways, or as vapors from the substance volatilize into the atmosphere or collect in such confined spaces as culverts and sewers. Biouptake by plants and soil organisms is another transfer mechanism of soil contaminants and one which introduces the contaminants to the food chain.

Contaminants with high soil adsorption coefficients (e.g., benzo-a-pyrene) may bind (adsorb) to the surface of soil particles through ion exchange and become relatively immobile under certain conditions. However, adsorbed contaminants may later be desorbed by percolating waters, causing the contaminants to become mobile again.

Water

Water contamination poses an ingestion and a direct contact threat. Water also transports contaminants through soil and acts as a vehicle for intermedia transfer of contaminants to air and soil. Water has two important characteristics: its strongly dipolar nature and the ability of water molecules to form hydrogen bonds with the oxygen ends of adjacent water molecules. The dipolar nature of water is the reason for its solvent properties; the force of attraction between the dipole and ions on the surface of a contaminant or other substance can cause the contaminant to form a solution with water.

The ability of water molecules to form hydrogen bonds with each other accounts for the high dynamic viscosity and high surface tension of water, as well as its melting and boiling points. Both the viscosity and surface tension of water affect transport of particulate material and the movement of ground water. Viscosity and surface tension both decrease as temperature increases.

The properties of the contaminant are important to consider when assessing the threat posed by water contamination. Such characteristics as solubility, vapor pressure, specific gravity, and dispersability affect the behavior of the contaminant in water and influence cleanup techniques.

DISPERSION MECHANISMS

Direct surface water contamination occurs from releases into a body of water or from contaminated runoff. Dispersion of contaminants through surface waterways is affected by currents and eddies in rivers, streams, lakes, and estuaries, and also by thermal stratification, tidal pumping, and flushing. Contaminant concentrations in rivers or streams can be estimated on the basis of rate of contaminant introduction and dilution volumes. Estimates of contaminant concentrations in estuaries and impoundments are more difficult to make because of the variety of transport mechanisms that may be involved, causing contaminants to remain concentrated in local areas or to disperse rapidly.

Direct ground water contamination can occur from liquids and solids in lined or unlined landfills, from lined or unlined lagoons, from underground storage tanks, from injection wells, or from long-term surface dumping. Dispersion of contaminants through ground water is influenced by a variety of factors such as the hydraulic conductivity of soils; the hydraulic gradient; the presence of impermeable subsurface barriers; the presence of discharge areas (e.g., streams that intercept ground water flow), and the presence of fissures, cavities, or large pores in the bedrock.

INTERMEDIA TRANSFER MECHANISMS

An important intermedia transfer mechanism in surface water is contaminant transfer to bed sediments, especially in cases where contaminants are in the form of suspended solids or are dissolved, hydrophobic substances that can be adsorbed by organic matter in bed sediments. Transfer between surface water and bed sediments is reversible, and the sediments can act as temporary repositories for contaminants, gradually releasing contaminants to surface water. In

addition, adsorbed or settled contaminants can be transported through migration of bed sediments.

Surface water contamination can be transferred to ground water in areas of significant surface water/ground water exchange (e.g., swamps, marshes) and to the food chain through edible plants and animals. Transfer to the atmosphere occurs where the surface water is contaminated with volatile substances. Such transfer can pose a threat of explosion as vapors collect in sewers and other enclosed spaces. High temperatures, high surface-area-to-volume ratios, high wind conditions, and turbulent stream flow increase volatilization rates.

APPENDIX 3

Sampling and Basic Data Interpretation

Together, sampling, sample analysis, and basic interpretation of analytical results form the most effective mechanism for obtaining definitive information to characterize site conditions, evaluate the threats to human health and the environment, support compliance and enforcement activities, justify site clean-up activities, and determine clean-up effectiveness.

The type and number of samples collected, the manner in which the samples are collected, and the analyses chosen depend on what the EPA investigator wants to prove. The sampling plan is the vehicle for securing a set of quality-controlled samples that reflect site conditions accurately and provide the information desired. The sampling plan outlines all sample locations, collection procedures, and analytical methods to be used in a sampling episode.

Once the samples have been analyzed by a laboratory, basic interpretation of the results can be confusing because of the different formats used by various laboratories to report analytical results. Nevertheless, there are a few standard terms used by laboratories to report the concentrations of the analytes. In addition, quality assurance parameters have been established through common laboratory practices to provide a means of measuring both the accuracy and precision of analysis and of ensuring that no external contamination was introduced by sample collection and analysis procedures.

This appendix is divided into three sections. The first section briefly covers the topics addressed in a sampling plan, the second section covers basic data interpretation, including qualifier codes used in sample analysis reports produced by laboratories in EPA's Contract Laboratory Program (CLP), and the third section covers data validation procedures.

Sampling Plans

Complete site sampling plans should address each of the following topics to ensure that the appropriate protocols are observed during the sample collection and analysis processes and to enable the sampling procedures to be duplicated, if necessary. Samples are not only used as a source of information for making site decisions, they may also be used for legal purposes, so complete documentation of the actual sampling event is important.

- **Representative Sample Locations.** Representative sampling locations depend on the purpose of the sampling activity. The intended data use will guide determination of the sampling locations and pattern and total number of samples. Contamination verification requires fewer samples biased toward suspected areas of contamination; such samples may not give an accurate presentation of the overall site characterization, however. A better overall characterization may be achieved using a grid pattern to determine sample locations. Use of a grid system generally increases the number of samples collected, thus increasing analytical costs.
- **Analysis Selection.** Specific parameters for analysis must be established while assembling the sampling plan. The laboratory should be notified and given the EPA-approved method number and the desired QA/QC information. The analysis selected influences the choice of sample equipment, volume, preservation, and holding time. A summary of sampling container type, preservatives, holding times, and analytical methods is included at the end of this section.

- **Sampling Equipment Selection.** The type of sampling equipment is dictated by the analysis selection, required sample volume, ability of decontamination, equipment composition, and cost. The sampling equipment should not introduce contamination into the sampling procedure. To avoid this, sampling equipment should be disposable or easily decontaminated. Disposable equipment must be economical or used when extensive decontamination would be required for durable sampling equipment. The equipment must also be functional, allowing a sampling team to collect samples quickly and efficiently. The composition or construction materials of sampling equipment must be considered so as not to contaminate the sample.
- **Sampling Volumes.** Sampling volumes are directly related to the types of chemical analyses that are requested. The laboratory requires a precise amount of a sample unique to the specified EPA-approved analysis or method. Providing the laboratory with an excess of sample volume increases the eventual disposal costs to the laboratory and in turn to the samplers. Providing the laboratory with insufficient volume can lead to increased field sampling costs and to delays.
- **Sampling Containers.** The type, size, and composition of sampling containers are directly related to the chemical analysis which is requested. The size of the container must conform to volume requirements specified in the EPA-approved method. The container must not release contaminants into the sample or absorb material from the sample. The container must ensure that ambient air cannot enter into the sample, and conversely, that gas from the sample cannot escape to the ambient air.
- **Sample Preservation.** Samples are preserved by means of environmental controls (e.g., cold storage) or chemical additives (e.g. nitric acid). The preservation method is directly related to the chemical analysis requested. The purpose of preservation is to keep the chemical constituents of the samples static during handling, packing, and shipment to the laboratory. Highly concentrated samples do not usually require preservation.

A128 SAMPLING AND BASIC DATA INTERPRETATION A128

- **Sample Holding Times.** The elapsed time between sample collection and laboratory analysis must be within a predetermined time frame known as the sample holding time. Each sample parameter has a prescribed holding time. Samples analyzed beyond the holding time are not truly representative of the sampling material.
- **Sample Identification.** Each sample must be identified and documented to ensure sample tracking is performed. A label is made for each sample, reflecting the site name, site location, sample number, date and time of sampling, sampler identification, preservative used, required analysis, and sampling location description.
- **Sample Custody.** Chain-of-custody forms are used to track the handling of samples once the samples are collected. The samples are documented as they are transferred from each handler or to the laboratory. The procedure is used to prevent sample tampering and to trace the path of a sample in the event of contamination offsite. Chain-of-custody seals are applied as directed by protocol.
- **Sample Transportation.** Samples may be hand delivered to the laboratory using government vehicles or they may be shipped by a common carrier. Packaging and shipment is regulated by the U.S. Department of Transportation in Title 49 CFR. Hazardous waste site samples should not be transported in personal vehicles.

A129 SAMPLING AND BASIC DATA INTERPRETATION A129

	Analytical Parameter	Matrix	Container Type and Volume (# container req'd)	Preservative degrees celcius	Holding Times	Trip Blanks (VOAs)	Analytical Method Ref.
	VOA	S	40 ml Vial (2)	4	7 Days	Yes	8240/SW-846
	VOA	W	40 ml Vial (3)	4*	7 Days	Yes	624/CLP
	BNA	S	8 oz Glass (1)	4	7 - 40 Days		8250 or 8270 SW-846
	BNA	W	32 oz Amber Glass (1)	4	7 - 40 Days		625/CLP
One Bottle Per Medium to test Pesticides/PCBs Together	Pesticide	S	8 oz Glass (1)	4	7 - 40 Days		8080/SW-846
	Pesticide	W	32 oz Amber glass (1)	4*	7 - 40 Days		608
	PCB	S	8 oz Glass	4	7 - 40 Days		8080/SW-846
	PCB	W	32 oz Amber Glass (1)	4*	7 - 40 Days		608
	P.P. Metals	S	8 oz Glass	4	6 Months		SW-846
	P.P. Metals	W	1 liter Glass or polyethylene (1)	HNO ₃ pH < 2 4	*** 6 Months		EPA-600/CFR 40
	Cyanide	S	8 oz Glass (1)	4	14 Days		SW-846
	Cyanide	W	1 liter Polyethylene (1)	NaOH to pH > 12 4	14 Days		SW-846

* If residual chlorine is present, preserve with 0.008% N₂S₂O₅

** Only required if dedicated sampling tools are not used

*** Exceptions - mercury (28 days) and hexavalent chromium (24 hours - water)

NOTE: Nitric acid (HNO₃)

Sodium thiosulfate (N₂S₂O₅)

Basic Data Interpretation

CONCENTRATION UNITS FOR ANALYSIS

Water (Aqueous)	ppm = ug/ml or mg/l ppb = ng/ml or ug/l ppt = ng/l
Soil or Sediment	ppm = ug/g or mg/kg ppb = ng/g or ug/kg ppt = ng/kg
Air	mg/m ³ , ng/m ³ (Temperature and pressure dependent) ppm or ppb (Unitless measurement)
Oils or Organics	The concentrations of oils or organics should be expressed using the soil units listed above. Laboratory results that report concentrations for oils or organics using water units should be questioned.

GLOSSARY OF SOME COMMON DATA QUALIFIER CODES AND TERMINOLOGY USED IN THE EPA CONTRACT LABORATORY PROGRAM (CLP)

CODES RELATING TO IDENTIFICATION

(indicate confidence concerning presence or absence of compounds)

U = Not detected. The associated number indicates the approximate sample concentration necessary to be detected.

(NO CODE) = Confirmed identification

A131 SAMPLING AND BASIC DATA INTERPRETATION A131

- B =** Not detected substantially above the level reported in laboratory or field blanks.
- R =** Unreliable result. Analyte may or may not be present in the sample. Supporting data necessary to confirm result.
- N =** Tentative identification. Consider analyte present. Special methods may be needed to confirm its presence or absence in future sampling efforts.

CODES RELATED TO QUANTITATION

(indicate positive results and sample quantitation limits):

- J =** Analyte present. Reported value may not be accurate or precise.
- K =** Analyte present. Reported value may be biased high. Actual value is expected to be lower.
- L =** Analyte present. Reported value may be biased low. Actual value is expected to be higher.
- UJ =** Not detected, quantitation limit may be inaccurate or imprecise.
- UL =** Not detected, quantitation limit is probably higher.

OTHER CODES

- Q =** No analytical result.

A132 SAMPLING AND BASIC DATA INTERPRETATION A132

TERMS

- **Accuracy.** Accuracy may be defined as the measure of the closeness to a true or accepted value.
- **Field Blank.** A field blank is a sample which is taken in the field prior to any sampling activities. Analysis of the sample will indicate whether contamination was introduced into the samples during the collection process.
- **Field Duplicate.** A field duplicate is a second sample (or set of samples) collected from one sample location and labeled for the laboratory as if it were a unique sample. Field duplicates are primarily used to check the precision and consistency of the sampling procedures used. The field duplicate can also act as a check on the analytical procedures.
- **Holding Times.** Holding times are the time frame within which the sample must be analyzed in order to ensure accurate measurement of the analytes. Holding times vary depending on the type of analysis to be performed.
- **Matrix Spike/Matrix Spike Duplicate.** A matrix spike describes a procedure in which a target compound at a known concentration is added to the sample during laboratory preparation to measure the accuracy of the analysis procedure. A matrix spike duplicate is a second run to determine the precision of analysis.
- **Method Blank.** A method blank is a sample which is prepared by the laboratory to determine if any contamination is being introduced during the extraction or analysis procedures.
- **Method Detection Limit.** The method detection limit (MDL) is the lowest concentration that can be measured if a sample is analyzed according to the method procedures.

A133 SAMPLING AND BASIC DATA INTERPRETATION A133

- **Performance Evaluation Samples.** Performance evaluation samples are samples of known concentrations that are available from either the EPA or the U.S. Bureau of Standards for submission with the field samples to the laboratory.
- **Precision.** Precision may be defined as the agreement between the numerical values of two or more measurements made in an identical fashion.
- **Relative Percent Difference.** The relative percent difference (RPD) is used to assess the variability of a measurement process. Typically, the value represents the difference between the matrix spike and the matrix spike duplicate. It can also represent the difference between two analysis runs.
- **Rinsate Blank.** A rinsate blank is a sample of rinsate—usually distilled water—from decontamination of sampling equipment. Rinsate blanks are used to qualify data.
- **Split Samples.** After it is collected, a sample to be split is thoroughly mixed, then divided into portions (splits) and the portions are sent to different labs for analysis. Samples can be split two or more ways, and the total sample volume depends on the number of splits and the analytic method to be used. Split samples are usually collected when a responsible party and EPA Enforcement or several government agencies are involved. Split samples act as a check on the laboratory.
- **Surrogate Spike.** A surrogate spike refers to a procedure in which a non-target compound is added to the sample during laboratory preparation to determine the extraction efficiency. Surrogate spikes are usually used only with organics.
- **Trip Blank.** A trip blank is a sample which is prepared prior to the sampling trip using distilled water. This sample travels to the assessment and is kept with the other samples but is not opened in the field. Analysis of the trip blank will ensure that the sample containers were not contaminated prior to the assessment.

Data Validation Procedures

Data validation is the process by which a qualified data reviewer ensures the quality of the laboratory analysis and the reported results. The procedures used to validate a data package vary slightly according to the type of analysis performed and the instrumentation used. Many times, data validation requires the reviewer to draw upon his or her analytical experience and expertise to make subjective decisions about the quality of a set of results. For this reason, data validation should be completed only by qualified persons.

Data validation procedures vary, depending on the type of instrumentation and methods used for analysis. For the sake of simplicity, the example below outlines the validation procedures for analytical results from a Gas Chromatograph/Mass Spectrometer (GC/MS). While validation of analyses performed on other types of instruments would not be an identical process, it would be similar.

EXAMPLE DATA VALIDATION PROCEDURES FOR GC/MS

- 1. Did the laboratory meet the holding times outlined by the sampling protocol?**
 - If yes, accept data.
 - If no, data should be accepted as estimates only.
- 2. Was the GC/MS properly tuned?**
 - If yes, accept the data.
 - If no, reject all GC/MS data because compounds may be misidentified.
- 3. Was the instrument properly calibrated?**
 - If yes, accept the data.
 - If no, data should be accepted as estimates only.
- 4. Were method blanks free of contamination?**
 - If yes, accept the data; no further action is required.
 - If no, determine if the contamination was the result of a common laboratory chemical. Sample data should only be rejected if the analyte concentration is less than three times the contaminant concentration in the blank.

5. Were field blanks free of contamination?

- If yes, accept the data; no further action is required.
- If no, determine if the contamination was the result of a common laboratory chemical. Sample data should only be rejected if the analyte concentration is less than three times the contaminant concentration in the blank.

6. Were the surrogate spike recoveries for all organics acceptable?

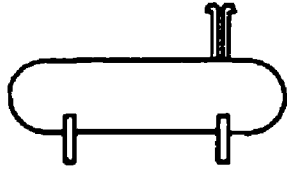
- If yes, accept the data.
- If no, evaluate each sample on an individual basis and accept or reject the data as necessary.

7. Were the matrix spike recoveries and the relative percent differences values acceptable?

- If yes, the laboratory has demonstrated good precision and accuracy; accept the data.
- If no, evaluate on per compound basis.

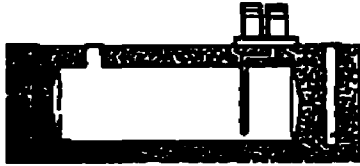
APPENDIX 4

Container Silhouettes



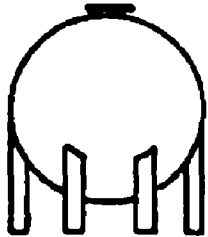
HIGH PRESSURE HORIZONTAL TANK

- STORES LP GASES, ANHYDROUS AMMONIA, HIGH VAPOR PRESSURE FLAMMABLE LIQUIDS.



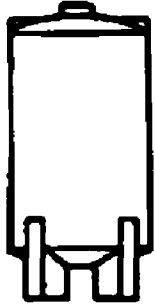
UNDERGROUND STORAGE TANK

- PRIMARILY STORES PETROLEUM PRODUCTS



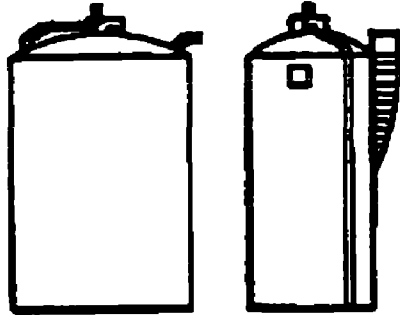
HIGH PRESSURE SPHERICAL STORAGE TANKS

- STORES LIQUID PROPANE GASES.



CRYOGENIC LIQUID

- STORES LIQUID OXYGEN (LOX), LIQUID NITROGEN, LIQUID CARBON DIOXIDE ETC.



DOME ROOF TANK

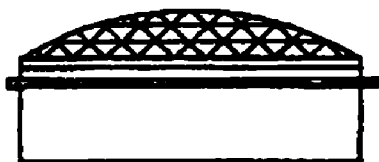
- STORES FLAMMABLE AND COMBUSTIBLE LIQUIDS, CHEMICAL SOLVENTS, ETC.

**CONE ROOF TANK**

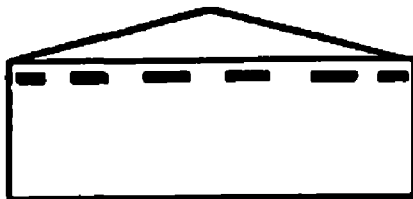
- STORES FLAMMABLE, COMBUSTIBLE AND CORROSIVE LIQUIDS.

**OPEN FLOATING ROOF TANK**

- STORES FLAMMABLE AND COMBUSTIBLE LIQUIDS.

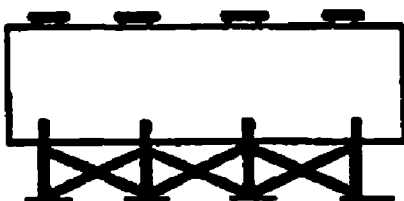
**OPEN FLOATING ROOF TANK WITH GEODESIC DOME**

- STORES FLAMMABLE LIQUIDS.



COVERED FLOATING ROOF TANK

- STORES FLAMMABLE AND COMBUSTIBLE LIQUIDS.



HORIZONTAL TANKS

- STORES FLAMMABLE AND COMBUSTIBLE LIQUIDS, CORROSIVES, POISONS, ETC.

APPENDIX 5

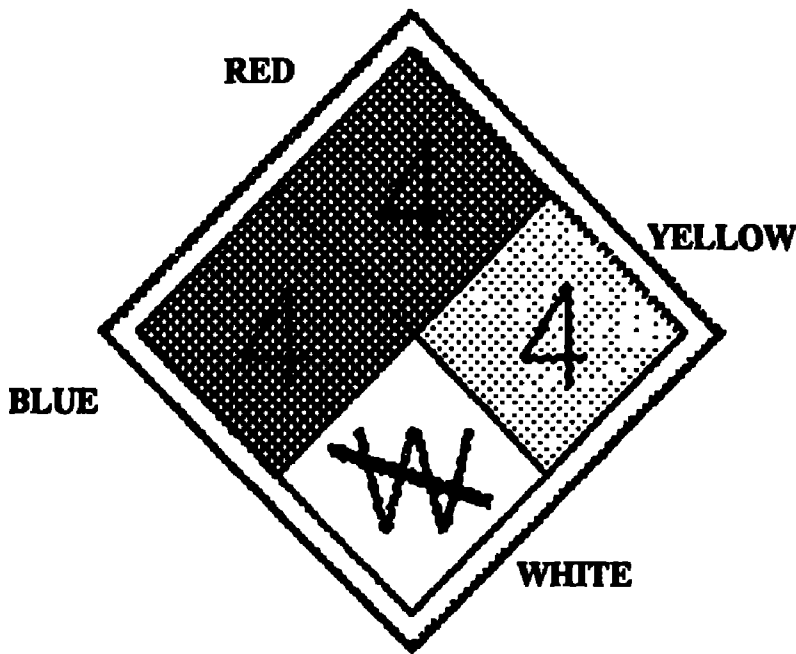
Guide to DOT and NFPA PLACARDS

The U.S. Department of Transportation (DOT) requires transporters of hazardous materials to display diamond-shaped placards on the outside of their vehicles to indicate the type of material being transported and the nature of its hazard. A DOT placard contains the following elements:



PLACARD RECOGNITION INFORMATION			
Hazard Class	Symbol	Colored Background	United Nations Hazard Class #
Explosives	Bursting ball	Orange	1
Gases (compressed, liquified or dissolved un- der pressure)	Flammable		2
	Flame	Red	
	Non-flammable		
	Cylinder	Green	
Flammable liquids	Flammable		3
	Flame	Red	
	Combustible		
	Flame	Red	
Flammable solids or substances	Flammable solid		4
	Flame	Red and white vertical strip	
	Water reactive materials		
	Slashed W (W)	Red and white vertical stripes with blue top quadrant	
Oxidizing substances	Circle with Flame	Yellow	5 Division 5-1 Oxidizing substance or agents division 5-2 organic peroxides
Poisonous and infectious substances	Skull and crossbones	White	6
Radioactive materials	Propeller	Yellow over white	7
Corrosives	Test tube over hand/test tube over metal	White over black	8
Miscellaneous dangerous substances			9

The National Fire Protection Association (NFPA) has a standardized marking system (704M) to indicate the properties and potential dangers of hazardous materials contained in fixed storage facilities. The marking system may also be used on drums and other moveable containers, as well. NFPA placards consist of four diamond-shaped quadrants that together make a large diamond. Health, flammability, and reactivity are identified and rated on a scale of 0 to 4, depending on the degree of hazard presented. The placards contain the following elements:



HEALTH (blue)

- 4 =** Materials that on very short exposure could cause death or major residual injury even though prompt medical treatment is given. Examples of such materials are acrylonitrile, bromine, and parathion.
- 3 =** Materials that on short exposure could cause serious injury on a temporary or residual basis though prompt medical treatment is given. Examples include aniline, sodium hydroxide, and sulfuric acid.
- 2 =** Materials that on intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given. Examples include bromobenzene, pyridine, and styrene.
- 1 =** Materials that on exposure could cause irritation but only minor residual injury even if no treatment is given. Examples include acetone and methanol.
- 0 =** Materials that on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material.

FLAMMABILITY (red)

- 4 =** Materials (1) that vaporize rapidly or completely at atmospheric pressure and normal ambient temperatures and burn readily or (2) that are readily dispersed in air and burn rapidly. Examples include 1,3-butadiene, propane, and ethylene oxide.
- 3 =** Liquids and solids that can be ignited under almost all ambient temperature conditions. Examples include phosphorus and acrylonitrile.

- 2 =** Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur. Examples include 2-butanone and kerosene.
- 1 =** Materials that must be preheated before ignition can occur. Examples include sodium and red phosphorus.
- 0 =** Materials that will not burn.

REACTIVITY (yellow)

- 4 =** Materials that in themselves are readily capable of detonation or of explosive decomposition or explosive reaction at normal temperatures and pressures. Examples include benzoyl peroxide, trinitrotoluene (TNT), and picric acid.
- 3 =** Materials that in themselves (1) are capable of detonation or explosive reaction but require a strong initiating source, or (2) must be heated under confinement before initiation, or (3) react explosively with water. Examples include diborane, ethylene oxide, or 2-nitropropadene.
- 2 =** Materials that in themselves (1) are normally unstable and readily undergo violent chemical change but do not detonate, or (2) may react violently with water, or (3) may form potentially explosive mixtures with water. Examples include acetaldehyde and potassium.
- 1 =** Materials that in themselves are normally stable but which can (1) become unstable at elevated temperatures or (2) react with water with some release of energy but not a violent release. Examples include ethyl ether and sulfuric acid.
- 0 =** Materials which in themselves are normally stable even under fire exposure conditions and that do not react with water.

SPECIAL INFORMATION (white)

The white quadrant at the bottom of the NFPA label is for special information about the chemical. The quadrant may contain the letter "W" with a horizontal line through the center to indicate a material that is unusually water reactive; it may contain the letters "OX" to indicate a material with oxidizing properties, or it may contain the standard radioactivity symbol to indicate a material with radioactive hazards.

APPENDIX 6

Random Numbers Table

There are times onsite, particularly when using a sampling grid, that it is necessary to choose random numbers. The following table has been included to make the selection of random numbers easier.

To use the table, select a random way to enter the table. For example, if it is 0815 hours, begin 8 digits down and 15 digits across. To maintain randomness, the table must be entered in a random way each time it is used. Once the beginning point is chosen, the user can move up or down, right or left to obtain numbers within the desired range, until the appropriate set of numbers has been reached. For example, to select 20 random numbers from 1 to 50, the user moves through the table in an arbitrary direction, copying each number encountered that falls between 1 and 50, until the user has a set of 20 numbers. Numbers that are outside the range are discarded.

460256	990550	724070	737802
491224	534609	431005	849665
707636	479367	064746	794388
585627	958920	535513	903818
942152	084899	820904	307654
200613	149604	356527	761574
906482	079119	676625	725354
492923	136445	304694	691000
296424	874623	894116	760868
822418	339855	618781	475789
260906	524634	813711	893198
252087	070868	865684	915256
901978	223001	353865	866974
048043	031144	440422	324343
774815	804195	511160	192451
179524	812968	066140	033615
387719	243315	860305	645506
818895	399252	294107	889266
702116	156083	054130	767643
841642	663529	003717	753110

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