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Environmental Health Management after Natural Disasters

PAN AMERICAN HEALTH ORGANIZATION
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Foreword

Health sector representatives repeatedly have expressed their commitment to improving the environmental health conditions of the population they serve, as a vital part of the primary care approach that stresses prevention of disease over cure of avoidable illness. Despite longstanding recognition of the essential link between the environment in which people live and work and their enjoyment of good health, much progress has yet to be made in this regard. Gastroenteritis and diarrheal diseases take a heavy toll in the region of the Americas, especially on infant life; and water-borne and water-related diseases are still major causes of morbidity and early mortality.

The importance of environmental health was underscored by an extraordinary session of the United Nations General Assembly, which in 1980 declared the decade ending in 1990 as the International Drinking Water Supply and Sanitation Decade. Providing healthful environmental conditions for an expanding, increasingly urbanized population is a task that cannot be accomplished by the health sector alone. It requires the commitment of governments to a broad intersectoral approach—including education and housing—within the framework of economic and social development plans.

Yet it falls upon the health sector to provide leadership in determining environmental health needs and planning and executing measures to meet them. PAHO has developed a comprehensive plan of action for health strategies in the region of the Americas. High priority is given to the provision of drinking water and basic sanitation services. In the spirit of the International Drinking Water Supply and Sanitation Decade, PAHO's Member Governments have set 1990 as the target date to "provide safe drinking water and adequate sanitation services to the greatest possible number of inhabitants." Within the overall strategy of achieving Health for All by the Year 2000, that year has been set as the date to extend this coverage to all persons.

Natural disasters, to which many countries in the region of the Americas are prone, can seriously jeopardize progress made in the area of environmental health. Physical disruption of infrastructure and services is aggravated by the displacement of large sectors of the population. The consequent alteration in their daily environment has potentially hazardous health consequences. Too often, it has been necessary to spend scarce resources on emergency measures just to reestablish previously existing environmental health services. Progress in such circumstances is severely hampered.

The series of manuals on disaster preparedness being issued by the Pan American Health Organization is designed to respond to the call from member countries to "disseminate the appropriate guidelines and manuals" in order to assist health workers in the Americas in developing disaster preparedness plans and training the necessary human resources. Given the suddenness of their occurrence and the importance of speedy measures to prevent potential morbidity and mortality, natural disasters demand that a nation use appropriate technology and its own human resources during the immediate emergency. Dependence on outside resources can create a time lag that may have serious consequences for the health and well-being of the affected population.

This manual is intended to provide a framework to assist planners in the health and other sectors to incorporate in their action strategies measures to protect the population from the deleterious effects of natural disasters. If not taken into account ahead of time, disasters may wreak unnecessary havoc with environmental health services that were established at tremendous cost where resources are scarce. This will occur even in areas where clean water and adequate sanitary facilities have existed for a long enough time to be taken for granted. The manual also addresses measures that should be taken once a disaster strikes to diminish its long-term effects on the health of the population and to speed up the recovery process.

If the potential effects of natural disasters are considered and provided for in advance, serious health aftereffects may be averted, costly repairs may be reduced, and progress toward Health for All by the Year 2000 may be maintained despite adverse natural circumstances.

Héctor R. Acuña, M.D., M.P.H.
Director

Preface

Environmental health is defined as the control of those factors in the environment that may have deleterious effects on people's physical, mental, or social well-being. Because natural disasters expose people to danger by disrupting or threatening to disrupt their immediate environment, effective management of environmental health after a natural disaster is of primary importance.

Natural disasters often increase morbidity and mortality rates. Taking appropriate measures to maintain environmental health helps to reduce or eliminate the risks of preventable disease and death. Such measures contribute not only to the health of individuals in and near disaster-stricken areas, but they also contribute to decreasing the high costs of providing emergency health services in the aftermath of disaster.

The environmental health measures that must be considered after a natural disaster include the provision of appropriate shelter for individuals or groups of people left homeless; the distribution of safe and accessible water, first in sufficient quantities for drinking purposes and then for other domestic uses; and the protection and distribution of safe food products. Other measures that must be considered for the control of environmental hazards associated with disaster are sanitary evacuation of excreta, liquid wastes, and refuse; protecting populations from common vectors of disease in stricken areas; and promoting healthful living—particularly sanitary housing and basic personal hygiene.

To effectively manage environmental health during and after a disaster, it is crucial that a state of preparedness was in effect before the event actually occurred. During an emergency, success largely depends on exercising good, rapid judgment about appropriate re-

sponse measures. High-level decision makers therefore must be familiar with sound measures beforehand and should be given an accurate assessment of the disaster's specific effects as quickly as possible.

This document is intended to serve as a guide for those who may be called upon to make emergency decisions after natural disaster strikes. The recommended environmental health measures have been listed in the order of priority in which they should be taken during an emergency. However, each natural disaster is unique in the degree or type of emergency it poses. In response to any given disaster, decision makers may find it necessary to change the priority assigned to any particular measure.

The proper reordering of priorities will be greatly simplified if the principal objective of environmental health measures during times of emergency is kept in mind. The object is to protect the health of individuals who live in or near disaster-stricken areas by keeping the deterioration of environmental health conditions and services to a minimum. Implied is that the *specific objective of emergency measures is to restore environmental health conditions and services to whatever levels existed before disaster occurred, regardless of judgments about predisaster quality*. If predisaster quality was less than desirable, the risk of disease will increase only if environmental health conditions change for the worse, all other things being equal. Measures to improve preexisting conditions should be scheduled for the rehabilitation phase, not the recovery phase.

This document is divided into several parts. The first section primarily addresses the effects of natural disasters on environmental health conditions and services. In the second section, environmental health measures are described that should be undertaken in each of three time frames: the predisaster, disaster, and postdisaster periods.

Acknowledgment

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Part I

The Effects of Disaster on Environmental Health

An Overview

The adverse environmental conditions that may accompany natural disasters vary according to disaster type. Table 1 presents probable concomitants to the most common disasters.

Table 2 presents the relative severity of the effects of some common disasters on the environment. These disasters cause considerable deterioration of environmental conditions. Partial or total disruption of environmental health services is to be expected, particularly of the lifeline services, such as water systems, food production and distribution, transportation, and power. Increased population density results from the effects of disaster listed in table 2. This, in turn, disrupts normal community life by causing health-related conditions to worsen and increasing the need for environmental health services.

Effects of Disasters on Conditions and Services

The sudden creation of areas of high population density, such as camps for displaced persons where there has been no planning for the sanitary accommodation of large numbers of people, is one of the most typical ways in which disasters affect environmental health conditions and services. Because of their generally inadequate facilities and services, establishing camps can result in secondary health emergencies; consequently, even more time and scarce resources will be needed than are required to address the original emergency situation.

Disruptions or overloading of water supply systems, excreta and liquid waste removal systems, and solid waste disposal systems also are likely consequences of natural disasters. When excreta and liquid waste disposal systems are disrupted, the probability of water-borne and food-borne diseases increases. Other water-related diseases and

Table 1. Consequences by Type of Disaster

Disasters	Consequences
Storms (Hurricane, cyclone, tornado)	Destructive winds Flooding Heavy rains Landslides Power outages
Earthquakes	Destructive vibration Power outages Fires
Volcanic eruptions	Earthquake Tsunamis Fires Volcanic debris
Tsunamis (Sea surges)	Floods Power outages

general nuisances are also more likely to affect disaster-stricken populations. Whenever access to normal water sources is hampered or cut off, it is critical that authorities make sufficient quantities for human consumption available to the populations in need.

As sanitation decreases with the disruption of solid waste disposal systems, the contamination of food and water supplies and the proliferation of vectors increase the risk of disease. The bothersome conditions that accompany breakdowns in solid waste disposal may contribute to the mental stress that disaster victims undergo. The disruption of solid waste disposal systems also can create fire hazards in densely populated areas.

The growth of populations of vectors of diseases such as malaria, yellow fever, tularemia, and typhus is a further common consequence of natural disasters, particularly in areas where such diseases otherwise are incidental. As was experienced in the aftermath of disaster in Haiti, the interruption of established vector control activities can cause a resurgence of such diseases.[1]

1. Mason, J., and Cavalié, P. "Malaria Epidemic in Haiti Following a Hurricane." *American Journal of Tropical Medicine and Hygiene* 14(4): 1–10 (1965).

Table 2. Matrix of Effects of Natural Disaster on Environmental Health Services

Service	Most Common Effects on Environmental Health	Earthquake	Hurricane/ Tornado	Flood	Tsunamis
Water supply and waste water disposal	Damage to civil engineering structures	●	●	●	○
	Broken mains	●	◗	◗	○
	Power outages	●	●	◗	◗
	Contamination (biological or chemical)	◗	●	●	●
	Transportation failure	●	●	●	◗
	Personnel shortages	●	◗	◗	○
	System overloading (due to shifts in population)	◗	●	●	○
	Equipment, parts, & supply shortages	●	●	●	◗
Solid waste handling	Damage to civil engineering structures	●	◗	◗	○
	Transportation failures	●	●	●	◗
	Equipment shortages	●	●	●	◗
	Personnel shortages	●	●	●	○
	Water, soil, and air pollution	●	●	●	○
Food handling	Damage to food preparation facilities	●	●	◗	○
	Transportation failure	●	●	●	◗
	Power outages	●	●	◗	◗
	Flooding of facilities	○	●	●	●
	Contamination/degradation of relief supplies	◗	●	●	◗
Vector control	Proliferation of vector breeding sites	●	●	●	●
	Increase in human–vector contacts	●	●	●	◗
	Disruption of vector-borne disease control programs	●	●	●	●
Home sanitation	Destruction or damage to structures	●	●	●	●
	Contamination of water and food	◗	◗	●	◗
	Disruption of power, heat fuel, water supply waste disposal services	●	●	◗	◗
	Overcrowding	○	○	○	○

● Severe possible effect
◗ Less severe possible effect
○ Least or no possible effect

Finally, decreased standards of general housing sanitation and personal hygiene are among the most common effects of disaster upon environmental health conditions and services. When displaced persons move into areas in which physical structures have been damaged by the disaster, overcrowding often causes housing sanitation to decline. The lack of proper clothing, water, soap, detergent and basic cleaning and washing facilities makes it difficult to maintain usual standards of personal hygiene; as a result, there are increases in diarrheal disease, vector-borne diseases like typhus, and conditions like scabies in areas where they were already prevalent before the disaster.

Part II

The Management of Disaster-Created Environmental Health Conditions

Chapter 1

Factors to Consider for Effective Management

Deciding on Appropriateness of Measures

To alleviate conditions in disaster-stricken areas, appropriate measures must be taken to halt the deterioration of predisaster levels of environmental conditions and the disruption of environmental health services and normal community life. Environmental health control measures must be undertaken before and in the aftermath of disaster and, whenever possible, during the disaster itself. In determining courses of action at these various stages, a given measure should be judged not only according to its technical feasibility and the availability of resources, but also according to the extent to which the measure is directed at returning environmental conditions to predisaster levels.

Factors to consider in making decisions about actions include areas of priority of intervention, the priority of needs for the various environmental health services, and the availability of manpower. The major factor that determines the priority of areas for intervention is the presence or absence of disease-related risks in the areas in which disaster victims reside. The relative risk of disease merits particular attention in the peripheries of urban centers and in camps and other temporary settlements.

The highest priority should be accorded to environmental health services that are essential to the protection of the well-being of individuals in high-risk areas. The cooperation of persons in high-risk areas should be sought, and they should be actively involved in the provision of services. The minimum levels of necessary services that must be provided are the following:

1. adequate shelter for displaced persons
2. sufficient quantities of accessible drinking water
3. facilities for excreta and liquid waste disposal
4. protection of food supplies against contamination
5. the protection of individuals in affected populations against vector-borne diseases through vector control activities and through chemoprophylactic methods.

Unavailability of appropriate environmental health manpower can be a limiting factor in emergency intervention after a disaster. The use of locally available experts therefore should be given first consideration. Because they are familiar with the predisaster and socioeconomic conditions in affected areas, and—even more important—because they have experience in working under conditions similar to those of disaster-stricken areas, these individuals are usually best equipped to

J. Vizcarra Brenner/PAHO

Women collecting water from a common pump in rural Bolivia. Guaranteeing sufficient water is a health priority after natural disasters.

handle the emergency contingencies caused by natural disaster. In contrast, outside experts often are unfamiliar with both predisaster conditions and the particular environmental health standards of a given disaster-stricken area. Their lack of knowledge may in fact hinder the success of relief activities, so caution should be exercised when foreign experts are recruited.

The Timing of Emergency Measures

Environmental health problems created by natural disaster should be managed in three major phases. These are presented with recommendations about the appropriate timing for initiating the measures; the duration of the phases, however, will vary according to the nature of the problems created by each actual disaster.

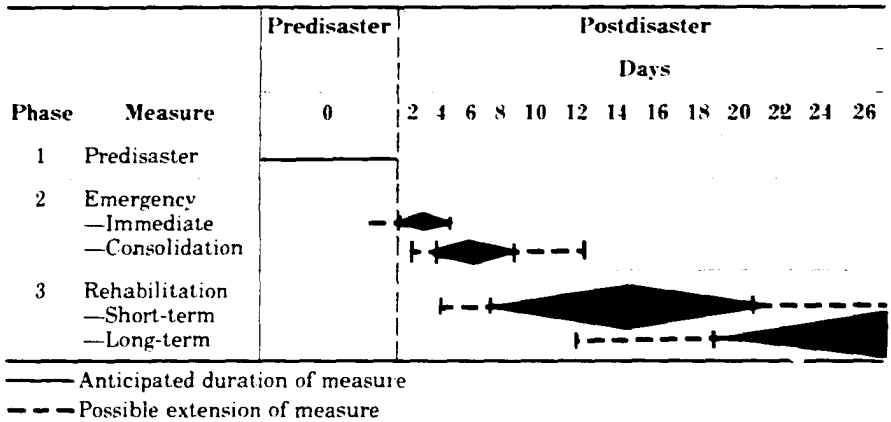
Phase One consists of measures undertaken before a disaster strikes in order to develop and maintain a state of preparedness. Preparedness planning focuses on areas of known high risk of natural disaster—areas with a history of occurrences, or areas that have been designated as sites of potential natural disaster.

Phase Two begins when the disaster strikes. The emergency-related activities of Phase Two are taken during the event, if possible, and in the aftermath of the disaster. Usually, the environmental health control measures of this phase take place within the first seven days following the disaster. They are, however, divided into subphases: *immediate measures*, taken within the first three days after the natural disaster strikes; and *consolidation measures*, initiated once the immediate measures of the emergency phase have been put into effect.

Phase Three involves the rehabilitation of the environment. Consideration of appropriate rehabilitation measures should actually begin as soon as the emergency-related measures of Phase Two have been initiated. Like Phase Two measures, those of Phase Three also take place in two subphases: *short-term measures*, to return environmental conditions and services to predisaster levels; and *long-term measures* of reconstruction, consisting of all the steps taken to improve environmental conditions and services that require long periods of time to accomplish.

It is recommended that all postdisaster measures except for long-term reconstruction activities be carried out within three weeks of the occurrence of the disaster. Table 3 presents a guideline for the timing

Table 3. Anticipated Schedule of Measures for Emergencies Created by Natural Disasters



of the adoption and completion of all postdisaster measures.

The specific environmental health measures that should be taken during each of these phases are elaborated in the following chapters. Although exhaustive discussion of long-term measures for rehabilitation is beyond the scope of this document, some basic recommendations are offered.

Chapter 2

Phase One: Predisaster Health Measures

Most natural disasters are sudden, and the warning period in which protective action can be taken is usually very short or nonexistent. With current technology we can at best predict some disasters only a few days before they strike. Often the warning is available only moments ahead of when the disaster hits. The only effective method of responding to a disaster, therefore, is to develop a state of preparedness in high-risk areas.

The principal objective of predisaster environmental health measures is to eliminate or reduce the hazards to environmental health in affected areas once disaster has actually hit. The way to achieve this is to develop a plan for environmental health control activity during the emergency, to adopt routine measures to protect environmental health, and to develop an emergency education and information program aimed at both public health personnel and the general population.

The Plan for Emergency Environmental Health Operations

Effective response to disaster depends heavily on planning the emergency environmental health operations. Once plans are drawn up, they should be revised every five to ten years, generally speaking. Actual experience with a disaster most likely will necessitate revisions immediately thereafter.

An emergency plan is not the *intention* to make a plan; rather, it is a well-developed but simply and clearly defined prescription for the *who*, *when*, and *what* of activities, using existent local resources, once disaster strikes. Guidelines and priorities for action should be stated in

the plan, but lengthy descriptions of the functions and duties of particular persons should be avoided. This is not to say that the functions and responsibilities of individuals within organizations are unimportant, but such descriptions usually emerge after it is determined how existing resources can best be used under the unique circumstances of each natural disaster.

The overall operations plan primarily entails a guide for coordinating all the activities that will be undertaken, after prediction (or occurrence) of the disaster, by personnel of the various types of environmental health and related services. Separate subplans should be developed for water supply service, solid waste service, and so forth. Detailed steps for the development of emergency plans by environmental health and related services are presented in Annex 1. The integration of these subplans forms the basis for finalizing the overall predisaster preparedness plan.

An overall plan contains seven basic components. The first is a statement of the extent of damage that is likely to result from the type of disaster to which the area is subject. The next three components consist of demonstrating how to estimate the resources that would remain after a disaster strikes; indicating how to calculate the needs of affected communities; and, finally, stating how these requirements will be matched with the resources. An assessment of vulnerability and of the inventories of supplies, equipment, and personnel yields the basic data for determining which emergency steps should be taken during the warning period (if there is one), the time immediately after impact, and the postdisaster period.

The last three components of the emergency plan are carried out after the disaster has taken place. These steps jointly make up the Emergency Operations Action (EOA) Plan. The EOA Plan should specify the schedule for addressing specific community needs (for example, providing food or shelter or water or sanitation before taking measures to ensure personal hygiene); indicate the best program for using existing resources; and assign specific tasks to environmental health control personnel assumed to survive the disaster. It must be stressed that the EOA Plan should be drawn up only *after* assessing existent measures.

At this point, it may be worthwhile to repeat the priority measures listed previously: to provide adequate shelter from inclement weather and ensure that the shelters do not burden environmental health

conditions and services: to provide at least the minimum quantity of safe drinking water; to remove human excreta and liquid and solid wastes from the immediate surroundings to nonharmful disposal sites; to bring the control of vectors to a level at which they will not transmit disease or affect the supplies of available food; and to ensure that food sanitation practices do not contribute to the spread of disease.

Finally, the emergency plan should be explicit about the way to disseminate information during the emergency period and about providing protection and accommodation for relief personnel. All relief workers should receive appropriate vaccinations. Personal protection in the form of clothing and washing facilities should also be ensured. Staff members should be instructed about the proper handling of equipment and supplies.

Protective Measures

Taking protective measures involves a wide spectrum of activities that range from considering appropriate design to putting decisions into effect before, during, and after a disaster. The most effective approach to planning such a variety of measures is to first review the effects of disaster, to then think about which protective measures mitigate the effects most common to *all* types of disasters, and finally to consider those measures that are related to specific disaster types or that are applicable to unique local conditions.

In reviewing the known effects of disasters on environmental health, it is evident that damage to civil engineering structures, the contamination of food and water supplies, power outages, and transportation failure all are of high probability and often are critical elements of a state of emergency. Appropriate measures to counteract each of these effects will be discussed.

Civil Engineering Structural Damage

Any natural disaster can destroy or severely damage civil engineering structures: buildings; water structures (such as pipelines, pumping stations, intake structures, and dams); retaining walls; electrical poles; roads; and platforms. Damage of these structures can cause casualties to nearby individuals, and it may lead to either partial or total disruption of lifeline services to the communities they serve.

Making advance preparations for the possibility of destruction and modifying existing facilities are major ways in which the damage can be reduced or eliminated. Structures can be reinforced to withstand the impact of a disaster. Likewise, the anchorage and support of machinery, equipment, and storage tanks can be improved. Bypass facilities can be provided; for example, in preparation for the possibility that a water plant, its equipment, or processes may fail, the plant can be bypassed to a point where raw water can be chlorinated. Finally, the adoption of standard operating rules and procedures will maximize readiness for any disaster.

Another way to reduce the impact of disaster on civil engineering structures is to improve the planning of the data base and of design standards. Conducting meteorological, topographical, hydrological, geological, and soil engineering studies in newly chosen sites will enable planners to avoid vulnerable locations. Vital structures can be located in areas known to be protected from the impact of disasters. Specific design methods can be prepared, used, and updated to protect structures, equipment, and supplies from disaster. For example, water distribution reservoirs can be sized with a storage factor of 1 1/2 to 2 times their normal capacity in order to guarantee emergency supplies.

Contamination of Food and Water Supplies

Contamination of food or water is one of the major public health hazards associated with the occurrence of disaster. Contamination can take place at the source of the supply, during transport, at the treatment or processing plant, during storage, or at various times during distribution. The primary cause of contamination after a disaster is damage to civil engineering structures.

Unless there are good reasons to suspect that chemical contaminants have found their way into food or water supplies, microbiological contamination should be the first concern of the decision maker in emergency cases. It is recommended that means to identify and monitor microbiological (and, whenever possible, chemical) characteristics of food and drinking supplies be found in emergency periods. Food analysis, however, is feasible only if the requisite laboratory services were available prior to disaster. Highly technical resource requirements make analysis of food products more difficult than that of

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A water caretaker in Saint Lucia diverts surface water to a reservoir for disinfection. Preparedness includes assessing the vulnerability of water treatment plants and reservoirs.

water. Inspection techniques and field test kits can be used for a quick assessment of food contamination.

Other measures to avert the effects of contamination are to identify alternative sources of safe food and water if regular supplies are unusable, and to identify standby or portable water processing or treatment units for use if the system fails. When economically feasible, means should be provided to drain or reduce water supply levels as quickly as possible and to use large dilution capacities to reduce the strength of contaminants. Actions to take against contaminants in the vicinity of source supplies need to be devised.

Power Outage

Power outage—mostly due to damaged transmission lines, damaged civil engineering structures, and equipment failures—is a common occurrence both while a disaster is in progress and in its aftermath. Outages tend to exacerbate problems with delivering lifeline services. They cause the disruption of operations in pumping and treatment plants in water systems and in pumping fuel. They also interfere with the refrigeration essential for safe food storage, and they limit the ability of hospitals to provide their services.

Measures to overcome the effects of power outages include providing nonelectrical means of maintaining limited power distribution (by taking advantage of gravity flow in providing water supply, for example) and supplying alternative electrical and auxiliary power systems to such critical facilities as pumping stations, processing and treatment plants, and hospitals. It is better to use portable generators than standby generators. Fuel for auxiliary power must be stored in sufficient quantities for three to five days of operation. Finally, power systems should be designed to allow the bypassing of plants and equipment, thus preventing total disruption of service when power fails.

Transportation Failure

Transportation is critical to the success of disaster relief efforts. Its failure can cripple the provision of lifeline services, particularly water and food supply distribution and solid waste disposal.

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All means for transportation of water during an emergency should be identified.

The effects of transportation failure can be reduced by constructing alternate secondary roads to vital locations of the water supply system. All other means of transportation that can be used during the emergency also should be identified. Rough terrain vehicles, such as those with four-wheel drive, and animal-traction vehicles are particularly useful after disaster. They are excellent for transporting both people and goods over short distances. In addition to taking these measures, a list should be prepared outlining the priority means of transportation to be available in the aftermath of disaster.

Basic materials, such as chemicals and spare parts, should be stockpiled against the possibility of transportation failure. It is recommended that arrangements be made with local distributors of chemicals, fuel, spare parts, and food to stock a small percentage of essential items that can become available during an emergency. In Barbados, for example, an agreement has been reached with local distributors of food to keep enough of certain items in stock to last five days. This not only guarantees the availability of essential foods after disaster, it also eliminates the costs of maintaining food stocks for long periods by the national relief organization.

Education of Personnel and the Public

A primary consideration in developing a state of preparedness in a disaster-prone area is the proper education of both personnel and the public. Each environmental health service, public and private, must develop training programs for emergency operations. Such training programs may offer an orientation course to all personnel about emergency measures for natural disasters. The course should be of a general nature, providing information regarding what may happen, what can be done by whom, and how to do it. It should be repeated at least once a year as a means to instruct new personnel. The course should be complemented by a more detailed one prepared for essential emergency personnel—employees selected for training to perform certain tasks in emergency situations.

A program for preparedness also should include training exercises. Periodic drills are important for personnel to practice emergency operational measures. The training program can be reinforced by special courses about emergency situations or by conferences, seminars, and printed material about natural disasters.

Public education is of utmost importance in emergency situations. The aim of a public education program should be to win the acceptance of disaster preparedness in disaster-prone areas. Awareness of the emergency measures that may be necessary and of what may be expected of the public is a major step toward the reduction of operational problems.

Chapter 3

Phase Two: Measures Taken during Disaster and in the Aftermath

The emergency environmental health control measures of Phase Two are divided into three time frames, and these immediate emergency periods are followed by a period of consolidation. The first of the emergency periods, the *warning* period, is a few hours or a few days in duration. The second, the *disaster occurrence* period, lasts from a number of seconds or, when the onset is slow, a number of days. The third, the *postdisaster immediate emergency* period, lasts three to four days after the disaster. The consolidation period may also last three to four days. There are a number of measures to be taken in each of these spans of time.

Emergency Warning Period

Emergency environmental health control measures should be put into effect as soon as warning is received that a disaster is imminent (this obviously applies only in such cases where warning is available). The goals of environmental health management in threatened areas are to protect the population and to ensure a state of preparedness and the availability of water, food, shelter, and clothing.

Specific measures to be taken in the warning period include informing and mobilizing personnel of all environmental health services. Inventories should be obtained of the available recommended health personnel, equipment and supplies needed to address anticipated contingencies. Key elements of water and food supply and human waste systems should be protected against impact. The threatened

population should be informed about appropriate measures to take for self-protection. They should be requested to store ample quantities of water in clean containers, such as bathtubs.

If the onset of disaster will be relatively slow, as in the case of some floods or hurricanes, the criteria for a number of measures should be reviewed and disseminated. Among these criteria are those for the establishment of emergency shelters in camps or buildings, the use and development of resources, and proper procedures for issuing requests for aid.

Disaster Occurrence Period

The rescue and accommodation of displaced persons are the objectives of measures taken during this period. During rescue operations, special attention must be given to the establishment of camps for displaced persons. Environmental health technicians should be included as members of the teams that determine the criteria for choice of campsites and design of camp layouts. *This step is particularly important because once people are settled in particular locations, it is difficult to ask them to move again.* Areas proposed for accommodating displaced persons must be surveyed in order to determine whether basic environmental health services can be provided and whether use of the sites might upset the environmental health services of the area or of surrounding areas.

If the natural disaster persists, the impact of its progression should be monitored. Damage should be evaluated at this time and personnel should draw up lists of priority measures to resolve the problems identified.

Immediate Postdisaster Emergency Period

There are five major concerns to address as soon as the full impact of the disaster begins to diminish and the relief effort can be initiated: making basic quantities of safe drinking water available to the general populations and essential users; providing safe, adequate shelter to stricken populations; protecting water and food from contamination by human waste; ensuring that victims follow the principles of basic

personal hygiene; and protecting the affected populations against vector-borne diseases that are prevalent in the disaster-stricken area.

Addressing these concerns effectively will depend on evaluating the disaster's impact on environmental health conditions and services. Thus, an initial survey is required of the availability of health and other related services in the stricken areas. Particular focus should be placed on public supplies of water and food, human and solid waste disposal, housing, and power systems. An inventory is necessary of available resources, essential personnel, equipment, supplies, and logistics that can be used to meet immediate needs.

To determine which areas merit greater attention because of multiple risk factors for disease and other hazards of high population density, information should be gathered about population movements within or near stricken sites. For example, the presence of partially or totally evacuated areas and of settlement sites for displaced persons and relief workers needs to be known.

The specific environmental health concerns that must be addressed in the immediate postdisaster emergency period are described in detail below.

Water Supply

Drinking water, *the* most essential item provided to disaster-stricken populations, is both indispensable to the support of life and a major medium of disease transmission. Thus, although provision of adequate amounts of water for drinking purposes is of utmost importance after disaster, it is simultaneously necessary to ensure the potability of the water used for drinking in affected sites.

Adequate drinking water should first be made accessible to victims and relief workers and in essential locations, such as hospitals and treatment centers. Water can then be made available in peripheral areas of urban centers and in densely settled rural areas and scattered rural sites. After drinking water is secured within stricken areas, making water available for domestic uses (such as cleaning and washing) should be considered.

Drinking water should be obtained from operational water distribution systems. However, it also should be sought from undamaged,

private sources (such as power plants, breweries, and other similar establishments); from undamaged springs, wells, or rainwater cisterns; and from newly constructed water structures, such as bore-holed wells. All water supplies must be carefully evaluated in order to eliminate the risk of water-borne infection and poisoning. The advice of an environmental health specialist (e.g., a sanitary engineer or sanitarian) should be sought when auxiliary water supplies are chosen.

Water suspected of contamination by human or chemical waste should not be used until it has undergone laboratory analysis. Sources located in the vicinity of sewage outfalls, chemical plants, solid waste disposal fields, abandoned mines, and other hazardous places should be considered suspect until such time that an environmental health specialist familiar with local conditions recommends otherwise.

Water delivered to disaster-stricken populations must be kept safe until consumed. This is ensured by disinfecting all supplies, particularly from surface sources and flood structures (such as wells, reservoirs, and rainwater cisterns), within stricken areas. The systematic disinfection of unaffected supplies is not necessary, however; this would be wasteful of the already scarce human and material resources. Proper health education should suffice to reduce the use of unsafe water supplies.

Ensuring the safety of drinking water is a function of a large number of measures. First, water should be tested for the presence of *Escherichia coli* and unsafe concentrations of nitrate as soon as possible. Detection of *E. coli* indicates contamination by human waste and therefore requires immediate protective and corrective measures. High concentrations of nitrate are extremely dangerous for infants, so this age group must be protected.

The residual concentration of chlorine in the distribution system should be increased after disaster. This reduces contaminants that can enter the system because of inadequate water treatment and allows detection of any water already contaminated that penetrates the distribution system. The dangers posed by water collected and stored in a nonhygienic fashion also will be diminished.

From previous experience we know that great care must, however, be taken to avoid overchlorination of drinking water. It is important to ascertain that supplies, especially of public water, are free of chlorine residual. Before chlorination begins, whether through the distribution

of tablets or the issuing of instructions for the use of household bleach, it is recommended that the chlorination program be supervised by an environmental health specialist.

The monitoring of water quality should be restored or initiated immediately. During this phase of emergency measures, daily determination of the chlorine residual in public water supplies is sufficient.

Increasing water pressure compensates for pressure loss due to the breaks of mains and helps to control contamination. It is imperative to consider the importance of water pressure in multistory housing.

If water supplies in the disaster area are not being chlorinated because chlorination systems within the distribution networks are not functioning, water must be disinfected in small quantities. This can be accomplished by boiling the water or by adding agents in the form of pills, powder, or solution. Methods for disinfecting small amounts of water that the Pan American Health Organization recommends are enumerated in Annex 2.

It is usually worthwhile to use mobile water purification plants during natural disaster emergencies if they are available locally. However, they produce limited quantities of water. In most cases mobile units are not essential and are of low priority in requests for aid. For the relatively minimal benefits they bestow, they are expensive; also, when shipped they occupy valuable space that is better used for drugs, medical supplies, food, and clothing.

Large volumes of water that will be hauled to camps or other settlements and to consumers in affected areas also should be disinfected. This can be accomplished with a chlorine compound (e.g., calcium or sodium hypochlorite) in the dosages and at the contact times recommended.

Tanks used for transporting and storing drinking water must be free of and protected against contamination. Mosquitoes should not be permitted to use such tanks as breeding sites. Tanks available locally from commercial water companies, dairies, breweries and so forth can serve to transport water if they are cleaned and disinfected before use. The general rule is to avoid placing drinking water in adapted gasoline, chemical, or sewage trucks and containers.

The final measure for protecting the safety of water is to repair and restore all public supplies. This should be undertaken immediately. All repaired mains, reservoirs, wells, cisterns, and similar units should be cleaned and disinfected.

Environmental Sanitation

Environmental sanitation measures are necessary for protecting the environment from the human wastes normally responsible for the contamination of food and water. Such measures also counteract the development of breeding sites of disease vectors and pests. Excreta disposal should receive primary consideration. Improper disposal not only leads to the contamination of water and food supplies; it also attracts flies and other disease-carrying pests. Other measures that should be taken are providing a sanitary solid waste system, including receptacles, means of transportation, and incineration and burial facilities at camps; providing a disposal system for liquid wastes; and restoring municipal disposal services.

For appropriate excreta disposal, trench latrines should be dug at camps and relief worker settlements. When this is not feasible, toilet facilities such as portable units should be provided. The trench latrines should be made accessible in densely populated areas if excreta disposal facilities have been destroyed. Tools and other materials should be given to the population, who should be instructed about constructing such facilities under the supervision of an environmental health specialist. Moreover, a health education program in latrine usage is essential to the sanitary upkeep of latrines.

As soon as excreta disposal systems have been provided, attention should be turned to public sewage systems. First, sewer lines and manholes that cause flooding in the streets and basements of densely populated areas should be unclogged. The next step is to repair sewer lines, manholes, sewer outfalls, and treatment units. Sewage tank trucks can be used to empty the overflow from septic tanks in public buildings used to accommodate displaced persons, casualties, and relief workers.

Shelter

As soon as rescue work has started, accommodating displaced persons under conditions that will not lead to the deterioration of public health and the environment should be considered. Immediately following a natural disaster, displaced persons usually seek accommodation with families or friends. In some cases, public shelter has to be provided temporarily until more permanent locations can be planned.

Existing public buildings—schools, meeting halls, churches, and hotels—often are chosen as temporary shelters because they can be converted easily into dormitories. They are also likely to have sources of water supply and waste disposal and bathing and washing facilities. Some even have cooking and mass feeding facilities.

It is important to underscore the fact that once individuals have been located and established on a site, it is difficult to ask them to move again. This point should be considered carefully especially in the establishment of camp settlements.

After the first two or three days following a disaster, more permanent shelters may become necessary. At this time, accommodating displaced persons should receive priority. To reduce the number of displaced persons who require shelter, they should be encouraged and assisted to stay with family or friends. As soon as possible, they should be helped to return to their own homes. If adequate resources exist to provide them with materials for constructing temporary shelter on their own property, this step should be taken. Wherever they locate, however, they must have access to water and food and a sanitary means of waste disposal.

J. Vizcarra Brenner/PAHO

The crowding and lack of sanitary facilities characteristic of temporary settlements create health hazards. Displaced persons should be helped to return to their own homes.

Accommodating displaced persons in tent camps should be considered only as a measure of last resort. The use of uncompleted public housing projects instead has, for example, proven a very effective way to provide temporary shelter.

Food Sanitation

Locally available food products can become degraded or contaminated as a result of a natural disaster. Food usually becomes contaminated by polluted flood waters and, in some cases, by disease vectors and by unsanitary handling, especially in mass feeding facilities. Degradation results from long periods of power outages that disrupt refrigeration and from contact with water, fradulent adulteration, and the use of old stocks of food products.

Since consumption of contaminated and degraded food leads to poisoning or infection, it has serious health implications. These consequences are best dealt with by locating available food supplies and investigating their fitness. Priority should be given to the consumption of uncontaminated, perishable food, particularly if the food supply originates in areas where there has been a power outage. *All* food, however, needs to be inspected. The analysis of food products should be of low priority, because it often is too complex an undertaking to initiate in areas affected by the disaster. Adequate inspection nevertheless can be made with simple kits for testing food, such as phosphate determination kits.

A qualified environmental health specialist should inspect all damaged places of food production and distribution before operations are carried out. The activities at mass feeding facilities also should be supervised by a specialist.

To avert health problems related to food degradation and contamination, the public should be informed about measures that can be taken to guarantee the safety of domestic supplies. The public should know which foods are safe to consume and the best methods of preparing them.

Vector Control

The impoundment of rain or flood water in empty receptacles or on the soil and other places creates unsanitary conditions because debris

and solid wastes accumulate, and it allows insects and rodents to proliferate. Certain diseases—malaria, yellow fever, typhus, tularemia, and diarrheal infections—are transmitted in this way; food supplies can be reduced; and other nuisances are created.

The goal of emergency activities is to control vector-borne diseases, especially where they are known to be prevalent. Environmental health control measures should be reinforced by other health measures (for example, chemoprophylactic efforts to control malaria).

Houseflies and rodents are nearly impossible to control in the aftermath of disaster. Environmental sanitation and personal hygiene measures are the only effective ways to combat the problems they create. Food and water should be stored in areas where flies and rodents cannot get to them, and all debris and solid wastes should be cleaned up and disposed of as soon as possible.

Many steps can be taken to ensure effective control of vectors during disaster-created emergencies.[2] All operations should be supervised by a qualified specialist in vector control, preferably one with experience in disaster-stricken areas.

Both the threatened population and specialists must work to eliminate breeding sites. The population should be informed about measures to eliminate such sites and about other means of protecting themselves from vector-borne diseases. Authorities should take permanent measures—drainage, filling, overturning receptacles, and so forth—to eliminate breeding sites. Locally obtainable larvicides should be utilized in large-scale water impoundments, since the direct elimination of such bodies of water requires excessive time, effort, and resources.

Potential breeding sites of mosquitoes should be identified by surveying campsites and other densely populated areas. These surveys should focus on specific diseases transmitted by the mosquitoes rather than on general mosquito control. Wherever malaria is prevalent, for example, the purpose of the survey should be to identify the breeding sites of the species of mosquitoes which carries malaria (the *Anopheles*).

These measures will greatly reduce the need to spray insecticides,

2. For detailed measures against specific vectors, see *Emergency Vector Control after Natural Disaster*, Pan American Health Organization, Scientific Publication No. 419 (Washington, D.C., 1982).

Marcelo Montecino/PAHO

Trash collection in Havana, Cuba, during the 1981 dengue fever epidemic. The sanitary disposal of trash and garbage is essential in vector control.

but outdoor spraying may be judged the best way to reduce proliferating adult mosquitoes. If this is necessary, locally available materials should be used. Use of sophisticated supplies and equipment is not recommended, because the benefits gained do not justify the high costs incurred.

If indoor spraying is to be used in flooded areas, it should be initiated as soon as possible. Flooded housing is of the highest priority for indoor spraying. In deciding whether to spray indoors, note that populations in tropical countries tend to stay outdoors; therefore, indoor or residual spraying of insecticides will not significantly reduce contact with vectors.

Finally, action must be taken against the spread of typhus. Displaced persons in settlement camps and other types of public shelter should be dusted. To control typhus in more established settlements, facilities for bathing and washing must be provided.

Personal Hygiene

Personal hygiene usually falls off in times of emergency, especially in densely populated areas, such as settlements for displaced persons. Consequently, the incidence of diseases associated with inadequate personal hygiene may rise.

Providing displaced persons with cleaning and bathing facilities will encourage attention to hygiene. Overcrowding in sleeping quarters should be avoided. Sufficient quantities of water should be made available to those who live in areas other than settlement sites and whose water supply has been interrupted. All disaster-stricken populations need to be informed about and encouraged to acquire the habits of personal hygiene that will protect them from disease.

General Public Information

In addition to the specific information stated in earlier sections, information should be made available to the public about such things as the location and kind of resources and environmental health services available, the location of settlement sites for displaced persons, and the names and titles of the authorities to contact to report emergency situations. This helps the public understand the extent of

the emergency, reduce confusion, and improve the effectiveness of emergency environmental health activities.

Environmental health measures applicable to emergencies created by natural disasters are summarized in Annex 3. These should be of value to decision makers in formulating and publicizing policies during emergencies.

Consolidation Period

A few days into the emergency period, those environmental health measures that have been taken should undergo consolidation. The measures to be accomplished in this period of consolidation include preparing lists of needed assistance and submitting them to relief agencies, receiving and distributing the aid, and establishing camps.

Providing Relief Agencies with Lists of Needs

By comparing current needs to the results of earlier surveys, one or several lists should be made of technical manpower, equipment, and supplies needed. Lists should be prepared for representatives of national and international agencies, giving priority to aid obtainable from local rather than foreign resources.

Receiving Aid

All aid received must be checked against the lists of aid requested in order to ensure that needed items actually have been provided. The suitability of equipment and supplies also needs to be checked; this may require assistance from a local expert, such as a chemist or an engineer. To avoid damage and waste of incoming aid, all equipment and supplies should be handled properly.

Distributing Aid

A list should be made of priority areas to receive aid. Distribution of goods should be guided by good judgment of actual needs so that local capabilities are not overwhelmed. When aid is distributed improperly, valuable supplies may be wasted.

Establishing Settlements for Displaced Persons

Safe water, food supplies, and basic sanitation facilities must be available in all camps for displaced persons. Sanitation teams, which will provide services and educate camp dwellers, should be designated for each campsite. Teams can be composed of volunteers, but they should be supervised by an environmental health technician. They should develop sanitation regulations for the sites and make the residents aware of them.

Finally, settlement dwellers must be encouraged to return to their homes as soon as they can do so safely. They should return to the sites of their homes even if they need to be given construction materials for erecting temporary shelters on their property.

Chapter 4

Phase Three: Rehabilitation Measures

Although *rehabilitation* implies the reconstruction of services to predisaster levels and therefore involves long-term postemergency activity, some rehabilitation measures have to be taken during both the emergency and immediate postemergency periods. Environmental health rehabilitation measures should be initiated as soon as possible in the emergency phase. The specific rehabilitation measures to be undertaken during the emergency phase are to restore lifeline services immediately, to return environmental health surveillance back to its normal state, and to evaluate the emergency operations plan once it has been implemented.

Restoration of Lifeline Services

All of the lifeline services—water supply, sewage and solid waste disposal, electricity, transportation, communication, and, in some instances, heating fuel—should be given primary consideration. The first short-term measure to address breakdowns in lifeline services is to create a national committee of representatives of all local and government service agencies and at least one environmental health specialist. The committee should assume responsibility for planning, monitoring, and coordinating all reconstruction activities. If necessary, a subcommittee for health and environment may be formed to oversee responses to specific public health problems.

Technical surveys for evaluating and planning the restoration of lifeline services should be conducted by specialists familiar with the affected areas and their predisaster conditions. They should gather information about specific equipment and supplies needed, in addition

to information concerning general reconstruction needs. The survey should enable officials to establish the order in which measures must be taken to achieve both the short-term and the long-term restoration of services.

Once the emergency period has passed, replacements for partially and totally destroyed supplies and parts will have to be purchased. The list of items to be ordered should be drawn up during the technical surveys. Purchase orders for these should be completed at the earliest possible time, since procurement frequently is delayed.

Supplies and parts should be ordered from abroad only if they cannot be purchased locally. In the same vein, expertise and manpower resources to carry out repairs and the construction of environmental services should be contracted locally whenever possible. The cost of manpower and material resources usually increases substantially in emergency situations; thus, employment of members of the stricken population is socially and economically beneficial.

Plans for restoring lifeline services should be designed to strengthen environmental health services in stricken areas. This may call for improving upon the human, material, and financial resources and operating methods of the predisaster services.

Restoration of Essential Environmental Health Surveillance Activity

Essential environmental health surveillance activities should be initiated or restored as soon as environmental health services are in operation. The purposes of surveying environmental health services primarily are to ensure that no increased risk of disease exists and to measure the progress of the activities conducted during both the emergency and rehabilitation phases. Only essential surveillance activities should be considered; it may be judged necessary, however, to develop special environmental health surveillance programs on either a short-term or a long-term basis. The essential activities discussed below are presented in order of importance.

Water Quality

Routine testing of chlorine residual in the water should begin immediately after the disaster occurs. Routine determination of levels

of *Escherichia coli* and nitrates should be initiated thereafter. Once municipal water distribution systems have been restored, routine testing should begin for chlorides, sulfates, magnesium, total dissolved solids, and pH level. If the concentration of chloride changes dramatically, it may indicate contamination of the water by human waste. The presence of high levels of sulfates, magnesium, and totally dissolved solid concentrations needs to be checked, because these can have a laxative effect.

Food Supplies

Utmost in importance is surveillance of the sources and quality of the water supply used in food preparation, the cleanliness of the premises where food is handled and prepared, washing facilities, sanitary storage of food supplies (including refrigeration), and facilities for sanitary excreta disposal. Testing of milk quality to determine

J. Vizcarra Brenner/PAHO

An open market, South America. It is important to monitor the cleanliness of areas in which food is handled and prepared.

if water has been added may be done routinely if phosphatase determination kits are available.

Environmental Sanitation

During this phase, surveillance of latrine construction projects, solid waste handling, and general sanitation in high-risk places (such as settlements for displaced persons, hospitals, and schools) should be restored or initiated.

Evaluating the Emergency Operations Action (EOA) Plan

Upon consolidating the emergency and postemergency measures, it is necessary to evaluate comprehensively all of the activities that have taken place. Both the strengths and weaknesses of the predisaster, emergency, and immediate postemergency measures should be underscored. This information can be used to improve the entire emergency plan handling postdisaster problems. It also reinforces policy decisions about rehabilitation, such as those concerning changes in the design and construction of civil engineering structures and replacing equipment and supplies.

The questions to be posed during the evaluation are the following:

1. What happened during the disaster?
2. What did not happen? Why?
3. Who was or was not there?
4. What should be done to improve the entire EOA Plan?
5. What laws or regulations need to be changed to improve the EOA Plan?
6. What material should be stocked for emergency use in the future?

The report of this final evaluation should be offered to the local governmental and nongovernmental agencies of concern and to international relief organizations. An evaluation of this kind will also ensure proper coordination of routine activities, essential for improving preparedness for the future occurrence of disaster.

Part III

Annexes

Annex 1

Developing an Environmental Health Emergency Operations Plan

Step 1: Identifying Organizational Resources

The first step in developing an environmental health emergency operations plan is to make an inventory of the organizations that will participate in the emergency activities and to assign members of these organizations to particular staffs and teams. Professionals, each working with an advisory committee, should be responsible for developing the plan and training the individuals who will participate in the relief effort. Contact should be made with civil defense, military, and other groups to learn about local contingency plans, to ask for help in planning for disaster, and to establish channels of liaison. The responsibilities of organizational staff members and teams and channels of command should be specified. In assigning individuals to the groups, alternates also should be designated. A list of names, addresses, and phone numbers should be made, including both regular and alternate members.

Step 2: Vulnerability Analysis

Assessing vulnerability is the second step in developing the plan. To assess the vulnerability of areas that may be stricken by disaster, it is necessary first to identify and describe the components of entire environmental health service systems and then to chart the characteristics of those natural disasters that might occur (floods, earthquakes, windstorms, and so forth). The effects of each type of disaster on each component of services can then be estimated. (If 50 percent of the water treatment plants serving a particular area might be damaged when disaster strikes, for example, the result might be that safe water can be

provided to only 15 percent of the affected population.) After these estimates have been obtained, the service requirements and the capacities of services to meet these requirements should be estimated. This estimation reveals the balance between the capacity of a service affected by disaster and the minimum estimated need for it in the population. If the capacity exceeds the estimated need, there is a margin of safety, and priority placed on that service can be relaxed. But if requirements exceed the estimated capacity of the service, this indicates a need to improve the service. Finally, the critical components of services should be identified.

Step 3: Allocating Resources

The third step is to specify priorities and establish the best program for using resources. Baseline environmental health levels should be determined. Needs and their priorities can then be established by allocating services under assumed postdisaster conditions, preparing guidelines for service allowances, rationing and deciding upon the timing of estimated needs, and selecting procedures for dealing with the conditions caused by disasters.

Step 4: Protecting Personnel

The fourth step is to make provisions for protecting personnel. A plan should be developed to test personnel with exercises to familiarize them with emergency procedures. The program for providing shelter should guarantee shelter to essential personnel.

Step 5: Inventory of Supplies and Equipment

In the fifth step, the equipment, supplies, and other materials necessary for the emergency are assessed. It is necessary to make inventories of those needs that will be essential for recovery, to plan to dispense them as necessary, and to provide security for them. Multiple copies should be made of the following records that will facilitate recovery:

1. maps and engineering plans
2. lists of regular and auxiliary personnel

3. lists of emergency supplies, including description of their availability and how to use them
4. inventories of items in stock
5. descriptions of emergency methods of operation and procedure

These records must be readily accessible to persons employed at all levels of environmental health services. Plans must be made for updating them and for keeping mutual aid parties informed of their contents and location.

Step 6: Coordination Agreements

In the sixth step, mutual aid agreements and other cooperative arrangements are initiated. Agreements with related services and civil defense agencies encompass the exchange or assignment of personnel, equipment, and supplies of the various cooperating groups. The coordination of reconnaissance and assessment, taking inventories, standardizing, training, and so forth also are covered in the agreements. Responsibilities should be defined and assigned, and legal limitations of cooperation should be considered.

Step 7: Specifying Emergency Measures

Once mutual aid agreements have been established, the seventh step follows: determining the actions to be taken during the emergency phase. The longer the period of warning, the greater the number of disaster readiness measures that can be accomplished. Disaster readiness measures include the following:

1. alerting and assigning personnel
2. undertaking abbreviated training
3. disseminating information to the public
4. increasing the protection of personnel
5. increasing the protection of structures and equipment
6. receiving emergency plans and procedures

The concerns of the warning period are personnel, plants and equipment, community action liaison, and public information. Con-

cerns of the period of impact are public information and, as limited by conditions, operations.

Step 8: Specifying Recovery Measures

The eighth step is to plan the postdisaster recovery. First, command must be assumed, and these actions must be taken:

1. activation of the disaster organization
2. mobilization of regular and auxiliary disaster relief staff members
3. the implementation of procedures for protecting personnel

Following this, the plan for maintaining or initiating liaison with members of relief services and mutual aid agencies should be developed. Procedures must be provided in time phases for the following:

1. reconnaissance
2. assessment of damage
3. determination of priorities
4. cleaning and decontaminating
5. initiating the operation of surviving facilities

The least of these measures consists of conserving water and food; isolating and repairing damaged facilities; monitoring environmental health factors, such as water supply; and advising the public.

Step 9: Improving Capabilities

The final step is to improve the capabilities of services if deficiencies are indicated. This is accomplished by increasing stocks of materials and supplies, developing auxiliary power sources and providing supplies of fuel, acquiring additional repair equipment, and recruiting and training personnel—volunteers, retired individuals, and other similar workers. The emergency plan must be improved and updated as a result of new additions. Finally, private benefactors who can augment local capabilities during emergencies should be identified, and a list of local consultants who can be called upon in emergencies should be compiled. All of these measures should be repeated at least once a year.

Annex 2

Guidelines for the Use of Tablet, Powder, and Liquid Disinfectants in Emergency Situations

Providing tablet, powder, or liquid disinfectants to individual users should be considered only when distribution can be coupled with:

1. a strong health education campaign in which people are instructed about how to use them
2. the distribution of containers for water storage
3. the assistance of public health or auxiliary personnel in providing the follow-up needed to ensure proper and continued use of the tablets
4. a network for distribution of additional supplies needed throughout the emergency phase and into the rehabilitation phase

In general, these disinfectants should be considered during an emergency for disinfecting small quantities of drinking water in limited and controlled populations, on an individual basis, and only for the limited time period of one to two weeks. Every effort should be made to restore normal chlorination facilities and to guarantee that water sources are protected.

Whenever disinfection is considered during an emergency, careful attention must be given to the initial condition of the water. Turbidity and color should be reduced as much as possible by allowing the water

Adapted from "The Pan American Health Organization Interoffice Memorandum: Provisional Guidelines on the Use of Water Disinfection Tablets following Natural Disasters" (Washington, D.C., 1979).

to settle or by straining it through layers of cloth. Once disinfected, the water should be stored in clear, covered, and noncorrodible containers. Before any form of disinfectant is provided to individual users for emergency treatment, public health personnel must be sure that the available sources of water to be used are not and have not been chlorinated. The chlorine residual should be determined before any disinfectant is distributed to individual users.

The most common agents that can be used to disinfect small quantities of drinking water under emergency conditions are chlorine, iodine, and potassium permanganate. Detailed discussion of each follows.

Chlorine Compounds

Tablets

The most common chlorine compound in use is known as Halazone tablets. Instructions for use of Halazone tablets are usually present on the bottle. If not, one tablet (4mg) should be used in each liter (approximately 1 quart) of water. If the water is turbid or highly colored the dosage should be doubled. The water should be stirred and left to stand for ten minutes before it is consumed.

Halazone tablets lose strength quickly once the wax seal on the bottle is broken. They should, therefore, be used as soon as possible, and the bottle should be capped between uses.

Higher strength tablets (160mg) are available in larger tablet size. Halazone (160mg) can be used to disinfect 40 liters of clear water or 20 liters of turbid or highly colored water. Care must be taken to not utilize Halazone (160mg) in the same tablet-to-water ratio as that prescribed for Halazone (4mg) tablets. Personnel involved in distribution should be aware of this precaution and should educate users.

Granular Calcium Hypochlorite

This dry powder, called HTH or Perchloron, contains 60 to 70 percent available chlorine. It remains quite stable when stored in tightly sealed containers in dark, dry, cool places. Once the container has been opened, it loses 5 percent of its initial available chlorine in forty days.

Care must be taken not to contaminate the powder with oil or combustible organic materials when it is mixed, because to do so may cause fire. To use HTH, add and dissolve one heaping teaspoon (approximately 1/4 ounce or 7 grams) per 2 gallons (8 liters) of water, thus producing a stock solution of 500 milligrams/liter. Add the stock solution to the water to be disinfected in the proportion of 1 part solution to 100 parts water. Let this stand for thirty minutes. If the taste of chlorine is too strong, allow it to aerate by standing another few hours or by pouring it several times from one clean container to another. The stock solution should be used within two weeks after it is prepared.

Sodium Hypochlorite Bleach or "Javel Water"

Common household bleach contains a compound that can, in emergencies, be used to disinfect water. The content of available chlorine (usually 3 to 10 percent) should be determined. It should be added to the water according to the following table:

Available chlorine	Drops/liter of clear water	Drops/liter of turbid or colored water
1%	10	20
4–6%	2	4
7–10%	1	2

If the strength of available chlorine in the bleach is unknown, ten drops of bleach should be added. After mixing the treated water, allow it to stand for thirty minutes. There should be a slight odor of chlorine. If not, repeat the dosage and allow the water to stand for fifteen minutes.

Iodine

Tablets

The most convenient and reliable iodine tablet forms are those that contain approximately 20 milligrams of tetraglycine hydroperiodine, 90 milligrams of disodium dihydrogen pyrophosphate, and 5 milligrams of talc. These tablets will dissolve in less than one minute at

about 20°C, liberating 8 milligrams of elemental iodine per tablet. This amount will be adequate to treat 1 liter of most natural waters within ten minutes.

Solutions

Common household tincture of iodine from a medicine chest or first aid kit (2 percent tincture of iodine) can be used to disinfect water. Five drops of tincture of iodine will be sufficient to disinfect 1 liter of clear water. For turbid water, however, add ten drops. Let the water stand for at least thirty minutes.

Potassium Permanganate ($KMnO_4$)

Potassium permanganate is seldom used because of its long contact time. It is usually considered as a disinfectant for large quantities of water in wells, springs, or storage tanks. Potassium permanganate is of doubtful efficacy against pathogenic organisms, with the possible exception of *Vibrio cholerae*.

To use the chemical, prepare a solution by dissolving 40 milligrams of $KMnO_4$ in 1 liter of warm water. The solution will disinfect approximately 1 cubic meter of water after twenty-four hours of contact time.

Annex 3

Technical Guide to Environmental Health Measures Taken in Response to Natural Disaster

This annex consists of a summary of recommendations. These are to be carried out during evacuation and relief operations.

Evacuation

During evacuation, water from suspicious sources must be boiled for one minute before it is cooled or it must be disinfected with chlorine, iodine, or potassium permanganate in either tablet, crystal, powder, or liquid form. The minimum amounts of water to be provided are:

3 liters/person/day in cold and temperate climates;

6 liters/person/day in hot climates.

Food must be nonperishable and should not require cooking.

Waste disposal should be in a shallow, all-purpose trench of the following dimensions:

10 centimeters deep x 45 centimeters wide x 3 meters long/1000 persons.

Relief Operations: Tent Camps

During relief operations, sites for tent camps should be chosen where the slope of the land and the nature of the soil favor easy drainage and where there is protection from adverse weather. Sites must be away from mosquito breeding places, refuse dumps, and commercial and industrial zones. The layout of the site should meet the following specifications:

1. 3–4 hectares of land/1000 persons
2. roads of 10 meters width
3. minimum distance between edge of roads and tents of 2 meters
4. minimum distance between tents of 8 meters
5. minimum floor area/tent of 3 square meters

Water distribution in campsites should consist of:

1. minimum capacity of tanks of 200 liters
2. minimum capacity/capita of 15 liters/day
3. maximum distance of tanks from farthest tent of 100 meters

Solid waste disposal containers in tent camps should be waterproof, insect-proof, and rodent-proof; the waste should be covered tightly with a plastic or metallic lid. The final disposal should be by incineration or by burial. The capacities of solid waste units should be:

1 liter/4–8 tents; or
50–100 liters/25–50 persons.

Excreta and liquid waste should be disposed in bore-holed or deep trench latrines in tent camps. Specifications for these are:

30–50 meters from tents;
1 seat provided/10 persons.

Modified soakage pits should be used for waste water by replacing layers of earth and small pebbles with layers of straw, grass, or small twigs. The straw needs to be removed on a daily basis and burned.

Washing should take place with an ablution bench that is:

3 meters in length;
double-sided;
2/100 persons.

Relief Operations: Buildings

Buildings used to accommodate victims during relief should provide the following:

minimum floor area of 3.5 square meters/person;
minimum air space of 10 square meters/person;
minimum air circulation of 30 cubic meters/person/hour.

There should be separate washing blocks for men and women.

Washing facilities to be provided are:

1 hand basin/10 persons; or

1 wash bench of 4–5 meters/100 persons and 1 shower head/50 persons in temperate climates;

1 shower head/30 persons in hot climates.

Toilet accommodations in buildings housing displaced persons should meet these requirements:

1 seat/25 women; and

1 seat plus 1 urinal/35 men;

maximum distance from building of 50 meters.

Refuse containers are to be plastic or metallic and have closed lids. To be provided are:

1 container of 50–100 liters capacity/25–50 persons.

Relief Operations: Water Supply

Daily consumption of water should be:

40–60 liters/person in field hospitals;

20–30 liters/person in mass feeding centers;

15–20 liters/person in temporary shelters and camps;

35 liters/person in washing installations.

Prescriptions for disinfecting water are:

for routine chlorine residual, 0.7–1.0 milligrams/1;

for disinfection of pipes, 50 milligrams/1 available chlorine for 24 hours contact; or 100 milligrams/1 for 1 hour contact;

for disinfection of wells and springs, 50–100 milligrams/1 for 12 hours.

For elimination of high chlorine concentration in disinfected water, use:

0.88 grams sodium thiosulfate/1000 milligrams chlorine.

To protect water, the distance between the water source and sources of pollution must be at least 30 meters. Wells can be protected by keeping the bottoms of cesspools and latrines 1.5–3 meters above the water table and with:

impervious casing 30 centimeters above and 3 meters below ground surface;

concrete platform around well of 1 meter radius;

fenced area of 50 meters radius.

Relief Operations: Latrines

Shallow trenches should be:
90–150 centimeters deep x 30 centimeters wide (or as narrow as can be dug) x 3–3.5 meters/100 persons.
Deep trenches should be:
1.8–2.4 meters deep x 75–90 centimeters wide x 3–3.5 meters/100 persons.
Bore-holed trenches should be:
5–6 meters deep;
40 centimeters in diameter;
1/20 persons.

Relief Operations: Refuse Disposal

Trenches used for disposing refuse should be:
2 meters deep x 1.5 meters wide x 1 meter long/200 persons;
covered with compact earth 40 centimeters deep. With these dimensions trenches can be filled in one week. The time to allow for decomposition of the refuse is four to six months.

Relief Operations: Food Sanitation

Eating utensils are to be disinfected with:
boiling water for 5 minutes or chlorine solution 100 mg/1 for 30 seconds;
quarternary ammonium compounds: 200 mg/1 for 2 minutes.

Relief Operations: Stocks

The following are important items of equipment and supply to be stockpiled for emergency environmental health:

1. Millipore sanitarian kits
2. comparators for chlorine residual or pH test kits
3. Hach DR/EL field test kits
4. pocket-type flashlights and spare batteries
5. water pressure gauges with positive and negative pressure
6. rapid phosphatase determination kits

7. mobile chlorinators and/or hypochlorinators
8. mobile water purification units of capacity of 200–250 liters/minute
9. tank trucks for water of 7 cubic meters capacity
10. easy-to-assemble portable storage tanks

Annex 4

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