Environmental Health Management after Natural Disasters

Study Guide and Course Text

Environmental Health Management after Natural Disasters

Study Guide for C280-BC02

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This Study Guide is one in a series of five prepared by the University of Wisconsin-Extension, Department of Engineering and Applied Science, Disaster Management Center with financial support from the Pan American Health Organization (PAHO). This self-study series is designed to use scientific publications of the Pan American Health Organization as texts for the study of health-related issues in disaster management. Each module of the series includes a PAHO text, a study guide, pretest, self-assessment tests and a final examination.

Legal Notice

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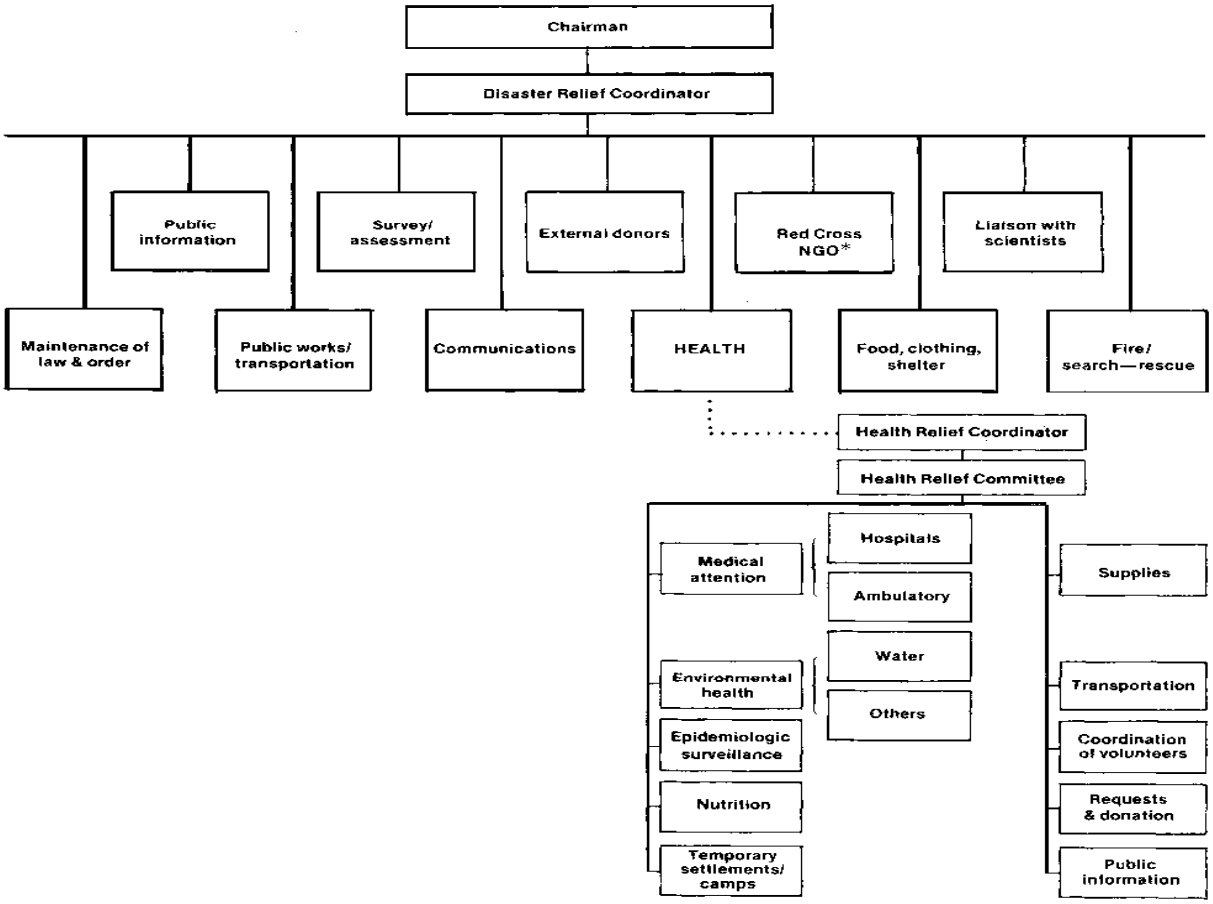
Foreward

In the event of a natural disaster, a nation, region, community or individual will return to normal more quickly if there has been advance planning on the use of available resources.

A plan to mobilize a country's resources for disaster management is a complex undertaking, as illustrated below.

The health sector must cooperate with other groups involved in the overall plan. In addition, they must work within the framework and priorities established by those in higher authority. Within the overall plan is a section dealing specifically with health and subplans for various units of the health sector. (See illustration.)

Organization of a National Emergency Committee



Coordination of Health Relief Activities

*** NGO = Nongovernmental organizations (also called voluntary agencies)**

Introduction

How to Get Started

This self-study course is designed to assist those responsible for meeting the health needs of people following a sudden natural disaster. It is designed for health care professionals, paraprofessionals, and those in training, as well as government personnel, and representatives of private voluntary agencies.

This course deals with disasters caused by destructive storms, earthquakes, volcanic eruptions, and sea surges. Specifically, it covers the effects of such disasters on environmental health.

The course is based primarily on the scientific publication, *Environmental Health Management after Natural Disasters,* published by the Pan American Health Organization.

The procedure of self-study is:

- Complete and score the Pretest. Do not be disappointed if you have a low score. if you had a high score, you probably do not need this course.
- Read the Outline of Content, to get a general idea of what is covered in the course.
- Read the Learning Objectives, to gel a general idea of what you are expected to learn from the course.

Turn to Lesson 1: An Overview.

- Review the Study Guide section for a brief description of the lesson and any special suggestions on how to study.
- Again read the Learning Objectives.
- Carry out the Learning Activities listed.
- Complete the Self-Assessment Test at the end of the lesson and score it using the answer key provided. If you have not answered most of the questions correctly, re-study the lesson.

If you score well on the Self-Assessment Test, proceed to Lesson 2.

Continue to study each lesson and complete each Self-Assessment Test until you have finished the course of study. When you have completed all the Self-Assessment Tests to your satisfaction, you should request the Final Examination Package. This will include the Final Exam and a Disaster Development Problem.

Pretest

Multiple Choice

Circle the correct answer(s):

1. An example of a natural disaster is
   a. disease epidemic
   b. an outbreak of food poisoning
   c. a hurricane
   d. mine explosion
   e. forest fire

2. The primary goal of a disaster preparedness plan is:
   a. to protect the population
   b. to protect valuable resources
   c. to keep communications lines open
   d. to protect environmental health personnel
   e. to procure needed funding

3. Priority environmental health concerns during a natural disaster are providing victims with:
   a. food, radio, water, portable generator
   b. food, fuel, refrigeration, shelter
   c. water, food, shelter, sanitation
   d. water, heat, clothing, medicine
   e. water, food, medicine, electricity

4. Disaster management is aimed *ultimately* at:
   a. resettling people in the closest unaffected urban area
   b. collecting valuable data for future management objectives
   c. strengthening sewage and drinking water treatment facilities to resist the impact of a future disaster
   d. incorporating needed reforms into community government structure
   e. restoring a community's services, facilities, and residences to predisaster levels

5. The most valuable information to have on hand in case a disaster strikes is:
   a. phone numbers and addresses of local, national and international aid societies
   b. knowledge of which areas are likely to be hardest hit and resources and services available in and around these areas
   c. first aid manuals, maps, and emergency operations manuals
   d. addresses of all hospitals and clinics throughout the country
   e. phone numbers of all communications media

6. Environmental sanitation involves:
   a. quarantining of areas in which individuals with communicable diseases are residing
   b. collecting, treating, and disposing of human waste to prevent risk of disease
   c. hygienic management of dairy and livestock operations
   d. spraying of areas with pesticides to reduce or eliminate disease risk
   e. treatment and disinfection of drinking water supplies

7. It is important to test the quality of the water because:
   a. it might transmit disease
   b. it might clog pipes
   c. it might stain laundry
   d. it might be unacceptable for use in food preparation
   e. it might be harmful to aquatic life

8. Educating the public on what to expect in the event of a disaster and what emergency steps to take:
   a. would lull the population into a false sense of security
   b. is an unwise use of time and money
   c. would increase the likelihood of survival
   d. could cause unnecessary panic and disorientation
   e. would eliminate the need for centralized disaster management

9. The most important use of water is:
   a. cleaning
   b. drinking
   c. bathing
   d. washing
   e. cooking

10. The major risk associated with overcrowding is:
   a. proliferation of mosquito breeding sites

b. heightened exposure to decaying matter
c. creation of nuisance problems
d. increase in mental stress
e. increase in diarrhea! disease

11. Relocation of disaster victims in camps:
a. is the preferred way to provide essential services to disaster victims
b. can result in secondary health emergencies
c. usually represents the most efficient use of scarce resources
d. should never be attempted

12. Once an area has been singled out as requiring priority intervention following a disaster, attention should turn next to:
a. determining high risk factors based on relative incidence of disease
b. instituting short-term rehabilitation measures
c. ranking the needs for essential lifeline services in order of priority and providing the requisite manpower
d. conducting technical surveys to evaluate and plan the restoration of lifeline services
e. assessing the technical feasibility of emergency measures

13. Predisaster environmental health measures are intended to reduce or eliminate environmental health hazards, caused or aggravated in a disaster, by:
a. developing evacuation strategies, coordinating transport and distribution of emergency supplies, and developing a public education program
b. developing an emergency operations plan, establishing an immunization program, and adopting routine measures to protect lifeline services
c. developing a public education program, conducting epidemiologic surveys, and coordinating transport and stockpiling of emergency relief supplies
d. developing an emergency operations action plan, adopting routine measures to protect lifeline services, and developing a public education program
e. assigning key military personnel to special emergency relief teams, organizing an emergency administration, and developing an emergency operations action plan

14. Delivery of enough water and food to stricken areas will depend largely upon:
a. national and international cooperation in stockpiling and distributing relief supplies
b. inspection and analysis of food and water supplies conducted by trained technicians
c. financing efforts organized on a national scale to purchase necessary goods and treatment units
d. willingness of local people to eat and drink products which taste unfamiliar to them
e. protective and emergency measures taken to keep vital transportation routes open

15. The primary cause of food and water contamination after a disaster is:
a. damage to civil engineering structures, such as dams, pipelines, etc.
b. large-scale looting of public and private facilities
c. difficulty in maintaining standards of personal hygiene
d. interruption of inspection and monitoring activities
e. personnel shortages

16. Alternate sources of drinking water may include all of the following except:
a. drinking water stored in gasoline containers
b. undamaged wells
c. breweries
d. power plants
e. rainwater cisterns

17. Tent camps should be located:
a. close to the nearest field hospital or emergency care unit
b. where slope and soil type favor easy drainage
c. where shelter material and vegetation are easily accessible
d. where the water table is no deeper than 3 meters
e. along a paved highway

18. Emergency environmental health control measures are carried out:
a. during phase two of a disaster
b. as soon as a warning is received
c. after the rescue and accommodation of displaced persons

d. only by qualified environmental health specialists
e. in response to requests from officials in the stricken area

19. Potential breeding sites of mosquitos should be identified by:
a. surveying areas where there has been an increase in vector-borne disease
b. surveying areas that sustained the heaviest flood damage
c. surveying areas of lush vegetation
d. surveying campsites and other densely populated areas
e. use of phosphatase determination kits

20. After mains, reservoirs, and wells have been repaired, they should be:
a. monitored weekly for chlorine residuals
b. put immediately back into service
c. cleaned and disinfected
d. inspected by a qualified environmental health specialist
e. lined with a water-proof sealant

21. If water is found to contain *E. coli* and dramatically increased levels of chloride, this may indicate:
a. contamination of water by insect vectors
b. presence of a chlorine residual
c. a possible laxative effect on the consumer
d. high salt levels, rendering the water unfit to drink but acceptable as an ingredient in food
e. contamination of water by human waste

22. Short-term rehabilitation measures are undertaken with three principal objectives in mind. They are: *(select three)*
a. make emergency information available to the public
b. prepare lists of needed assistance and submit them to relief agencies
c. restore essential lifeline services
d. locate sites for establishing tent camps
e. clear vital roadways and distribute emergency relief supplies
f. conduct technical surveys
g. restore environmental health surveillance activities
h. evaluate the emergency operations plan once it has been implemented

23. The should be determined before any disinfectant is distributed to individual users.
a. pH
b. chlorine residual
c. *E. coli* count
d. taste
e. nitrate level

24. All relief workers should receive:
a. appropriate technical aides
b. appropriate antibiotics
c. appropriate vaccinations
d. copies of the emergency operations action plan
e. first aid kits

25. All emergency, consolidation, and short-term rehabilitation measures should be carried out within of the occurrence of a disaster.
a. three days
b. three weeks
c. three months
d. six months
e. one year

26. Improper disposal of human waste can lead to: *(select the best answer)*
a. spread of disease
b. food spoilage
c. odor problems
d. fire hazard
e. fouling of water

27. Select the three primary areas of environmental health surveillance and list them in order of their importance:
___a. transportation
___b. sanitation
___c. communication lines
___d. power
___e. water quality
___f. food supplies
___g. shelter

28. When groups of displaced populations migrate en masse from the stricken area to other, unaffected areas:
a. sewage and water treatment facilities may become overloaded
b. it increases their likelihood of survival
c. they become more susceptible to disease

d. environmental health surveillance activities should be stepped up
e. they should be provided with disinfection agents in the form of a liquid, powder, or tablet

29. To assess the potential vulnerability of an area, one must first:
a. monitor food and water supplies and determine priorities of need
b. conduct hydrological, geological, and topographical studies of disaster prone areas
c. identify and describe components of the environmental health service system and chart the characteristics of those natural disasters that might occur
d. inventory equipment, supplies and other emergency materials and determine numbers of gas stations, retail food stores, and alternate water supply sources
e. determine areas of greatest population density and identify potential vector breeding sites in areas where vector-borne disease is endemic

True/False

Indicate T or F

___30. If the public water supply is found to be contaminated, mobile treatment units should be requisitioned automatically.

___31. Latrines should be inspected by qualified environmental health personnel.

___32. All food should be inspected and analyzed in the immediate aftermath of a disaster.

___33. There is usually a need for officials to provide large areas for emergency accommodation of homeless families.

___34. With current technology, we now can predict all disasters before they strike.

___35. Conducting technical and environmental health surveys are luxuries in the immediate aftermath of a disaster.

___36. The public should have accessible information about location and kind of resources and environmental health services available, and names and titles of authorities to contact regarding emergency situations.

___37. Some short-term rehabilitation measures must usually be taken during the emergency and immediate post-emergency periods.

___38. During a disaster, health-related agencies should act independently of one another to avoid confusion and disharmony.

___39. Personal hygiene is a primary consideration in relocation camps

Answer Key

1. c
2. a
3. c
4. e
5. b
6. b
7. a
8. c
9. b
10. e
11. b
12. c
13. d
14. e
15. a
16. a
17. b
18. b
19. d
20. c
21. e
22. c,g,h
23. b
24. c
25. b
26. a
27. e,f,b
28. a
29. c

30. F - Mobile treatment units produce limited quantities of water, are expensive, and occupy valuable space when shipped. However, they are worthwhile if available locally.
31. T
32. F - All food should be inspected, but analysis of food products is too complex an undertaking to initiate in areas affected by the disaster.
33. F - Most families appear to go to official shelters only when all other alternatives have failed.
34. F - With current technology, we can predict some disasters at best only a few days before they strike.
35. F - Accurate survey-taking enables officials to set emergency priorities for restoring essential lifeline services and ascertaining that no increased risk of disease exists.
36. T - When people are informed of what services are available, where to go and whom to contact, the effectiveness of environmental health activities improves.
37. T
38. F - Health-related agencies should exchange information and supplies, coordinate their activities, and share personnel. This helps avoid duplication and assures the best use of
manpower and resources.
39. T

Outline of content

Lesson 1 - An Overview
- Types of disasters
- Damage caused by sudden natural disasters
- Effects on conditions and services

Lesson 2 - Factors to Consider for Effective Management
- Factors in establishing priorities and determining courses of action
- Timing of emergency measures

Lesson 3 - Phase One: Predisaster Health Measures
- The plan for emergency health operations
- Developing an environmental health emergency operations plan
- Protective measures
- Education of personnel and public

Lesson 4 - Phase Two: Measures Taken during the Disaster and in the Aftermath
- Emergency warning period
- Disaster occurrence period
- Immediate postdisaster emergency period
- Consolidation period

Lessons 5 - Phase Three: Rehabilitation Measures
- Restoration of lifeline services
- Restoration of essential environmental health surveillance activity
- Evaluating the emergency operations action plan

Course objectives

Lesson 1 - An Overview
- Identify four types of sudden natural disasters.
- Be aware of their potential effects on essential lifeline services.
- Recognize the hazards to public health that could result, especially when large numbers of people are displaced.

Lesson 2 - Factors to Consider for Effective Management
- List three factors to be considered in determining a course of action in disaster management of environmental health.
- List the five necessary services that must be provided at least at minimum levels to individuals in high risk areas.
- Partition disaster management into three phases.

Lesson 3 - Phase One: Predisaster Health Measures
- Recognize the critical importance of detailed advance planning for effective management of environmental health services and resources in the event of a sudden natural disaster.
- Know the elements that go into developing an environmental health emergency operations plan.

- List the effects of natural disaster that are most likely to occur and create high health risks in certain areas.
- Know the protective measures that can be taken to minimize the effects listed in Objective 3 above.
- Explore ways to educate environmental health personnel and the public to prepare for and respond effectively to a natural disaster.

Lesson 4 - Phase Two: Measures Taken during the Disaster and in the Aftermath

- List the three time frames within phase two - that is, during and immediately following a natural disaster.
- Understand the principal objectives that should be met during each time frame.
- Know ways to assure safe food, potable water, facilities for sanitation and hygiene, adequate shelter, and vector control during and immediately following a disaster.
- Be aware of the necessity of keeping the population fully informed during this period.
- Know the measures to be taken during the period of consolidation, as steps toward recovery begin.

Lesson 5 - Phase Three: Rehabilitation Measures

- Understand the factors involved in planning for systematic restoration of environmental health services.
- List the six lifeline services that should receive the highest priority in short-term rehabilitation.
- Understand the purpose and application of technical health surveys during the rehabilitation phase.
- Consider when to take environmental health surveys, their order of importance, and basic parameters used for determining disease risk.
- Understand the importance of evaluating the emergency operations action plan and consider the types of questions that should be posed and to whom a final report should be sent.

Lesson 1 – An Overview

Study Guide

In this introductory lesson you should gain a general awareness that damage from sudden natural disasters disrupts environmental health conditions and services and consequentaly can affect the health of people.

Learning Objectives

- Identify four types of sudden natural disasters.
- Be aware of their potential effects on essential lifeline services.
- Recognize the public health hazards that could result.

Learning Activities

Read pages 3-6 in the manual.
Read, but do not memorize, Tables 1 and 2 in the manual.

Evaluation

Complete the Self-Assessment Test.

Lesson 1 – Self-Assesment Test

Multiple Choice

Circle the correct answer(s):

1. Relocation of disaster victims in camps:
   a. is the preferred way to provide essential services to disaster victims
   b. can result in secondary health emergencies
   c. usually represents the most efficient use of scarce resources
   d. should never be attempted

2. *Match* each lifeline service with one common effect a disaster could have on it:

Lifeline Service

___ water supply and wastewater disposal
___ solid waste handling
___ food handling
___ vector control
___ home sanitation

Effect

   a. increase in human contact with malaria mosquitoes
   b. water, soil and air pollution
   c. overcrowding
   d. system overloading
   e. contamination of relief supplies

3. If food and water supplies are contaminated by untreated human waste, the *greatest* concern is:
   a. creation of a fire hazard in densely populated areas
   b. lack of clean clothing and utensils
   c. creation of nuisance problems
   d. fouling of the food and water
   e. increased risk of disease
   f. resurgence of disease vectors

4. The major risk associated with overcrowding is:
   a. introduction of new vectors
   b. heightened exposure to decaying matter
   c. increase in mental stress
   d. increase in diarrheal Disease
   e. disruption of power and heat fuel

5. Which pair combines a *consequence* with the correct natural disaster (i.e. tsunami - volcanic eruption):
   a. winds - earthquake
   b. floods- hurricane
   c. heavy rains - tsunami
   d. fires - hurricane
   e. none of the above

6. Proliferation of disease vectors is of particular concern in areas where:
   a. water supply systems have been overloaded
   b. they were prevalent before the disaster
   c. they were not prevalent before the disaster
   d. solid waste disposal systems have been disrupted
   e. there is an increase in waterborne disease

7. Areas most deficient in adequate sanitation and washing facilities are likely to be:
   a. densely populated urban centers
   b. areas farthest from a centralized waste treatment facility
   c. widely scattered rural communities
   d. camps for displaced persons

8. It is absolutely critical that water be provided to disaster stricken populations:
   a. only after it has been disinfected
   b. where fire hazards have been created due to disruption of solid waste disposal systems.
   c. in quantities sufficient to satisfy drinking, washing, bathing, and laundering needs.
   d. in sufficient quantities for drinking purposes
   e. to enable sanitation measures to be carried out

True/False

Indicate T or F:

___9. In disaster preparedness planning, it should always be assumed and anticipated that a natural disaster will disrupt basic lifeline services.

___*10. Long and short-term effects on environmental health services will vary according to the type of disaster.*

Answer Key	
1b	6b
2dbeac	7d
3e	8d
4d	9t
5b	10t

Lesson 2 – Factors to consider for Effective Management

Study Guide
This lesson establishes the framework for effective disaster management of environmental health. It discusses criteria on which priorities are established and actions planned or taken. It defines three phases in disaster management that will be covered in detail in subsequent lessons.

Learning Objectives
- List three factors to be considered in determining a course of action in disaster management of environmental health.
- List the five necessary services that must be provided at least at minimum levels to individuals in high-risk areas.
- Partition disaster management into three phases.

Learning Activities
Read pages 9-12 in the manual.

Evaluation
Complete the Self-Assessment Test.

Lesson 2 - Self Assessment Test

Multiple Choice

Circle the correct answer(s):

1. The main reason that locally available experts should be called on first to take part in relief efforts is:
   a. they would most likely be immune to endemic diseases
   b. they would be familiar with pre- and likely postdisaster conditions in the affected area
   c. they would be trusted more by residents of the stricken area
   d. they would be the ones most in need of employment
   e. outside disaster personnel need not be diverted from other tasks

2. The major factor that determines what areas should be given priority for intervention once a disaster has occurred is:
   a. extent of property damage
   b. availability of manpower
   c. availability of medical personnel and drugs
   d. presence or absence of disease-related risks
   e. shortage of food and water

3. Preparedness planning focuses on areas where likelihood of___ is known to be high.
   a. infant mortality
   b. public ignorance
   c. natural disaster
   d. insect resurgence
   e. telecommunications failure

4. The first phase of environmental health management begins:
   a. long before a disaster strikes
   b. when a disaster strikes
   c. within the first three hours after the disaster has struck
   d. after the warning period
   e. at the moment local officials request help

5. The main objective of phase three is:
   a. to institute immediate emergency relief measures
   b. to focus on areas of known high risk
   c. to develop and maintain a state of preparedness
   d. to return environmental conditions and services to predisaster levels
   e. to initiate rescue and evacuation activities

6. Phase two is divided into:
   a. immediate and consolidation measures
   b. short-term and long-term measures
   c. emergency and rehabilitation measures
   d. predisaster and postdisaster measures
   e. emergency and control measures

7. After a disaster, as soon as an area has been singled out as requiring priority intervention, attention should next turn to:
   a. determining high risk factors based on relative incidence of disease
   b. determining the extent to which environmental health measures return conditions to predisaster levels.
   c. ranking needs of essential services in order of priority and providing the requisite manpower
   d. instituting short-term rehabilitation measures
   e. assessing the technical feasibility of emergency measures

8. Immediate emergency measures should be taken
   a. within the first three days after the disaster strikes
   b. within the first seven days after the disaster strikes
   c. prior to the disaster
   d. as soon as short-term measures have been initiated
   e. as soon as consolidation measures have been initiated

9. Consolidation measures should be initiated:
   a. once areas of known high risk of natural disaster have been designated
   b. once short-term rehabilitation measures have been implemented
   c. once long-term reconstruction measures have been implemented
   d. once immediate emergency measures have been implemented
   e. once local officials have been consulted

10. When considering emergency steps to take in the aftermath of a disaster, highest priority should be accorded to:

a. returning environmental conditions to predisaster levels
b. establishing settlements in peripheries of urban centers
c. immunizing the stricken population against typhus and malaria
d. protecting environmental health personnel
e. providing the minimum levels of essential services

True/False

Indicate T or F:

___11. Phase one consists of measures undertaken immediately after a disaster strikes.

___12. All phases of disaster management are Undertaken during time frames that overlap.

___13. The five necessary services that must be provided at minimum levels are: shelter, drinking water, food, vector control, and antibiotics.

___14. Environmental control measures are always undertaken before, during, and after a natural disaster.

Answer Key
1. b
2. d
3. c
4. a
5. d
6. a
7. c
8. a
9. d
10. e
11. F
12. T
13. F
14. F

Lesson 3 - Phase one: Predisaster health measures

Study Guide
This lesson begins the detailed presentation of how to prepare for a sudden natural disaster that could disrupt environmental health services. The information is presented in both Chapter 2 and Annex 1 of the manual. Since this gives a fragmented and sometimes confusing presentation, it is suggested that you read through the material once, and then go back and study it in detail in the sequence presented in the table at the right.

Learning Objectives
Recognize the critical importance of detailed advance planning for effective management of environmental health services and resources in the event of a sudden natural disaster.
Know the elements that go into developing an environmental health emergency operations plan.
List the effects of natural disaster that are most likely to occur and create high health risks in certain areas.
Know the protective measures that can be taken to minimize the effects listed in Objective 3.
Explore ways to educate environmental health personnel and the public to prepare for and respond effectively to a natural disaster.

Learning Activities
Read pages 13-15 in the manual.

Read pages 15-21 in the manual. Study the material in detail, in the sequence given in the table seen here. The page references are to Scientific Publication No. 430.

Read pages 43-46 in the manual (Annex 1).

Evaluation
Complete the Self-Assessment Test.

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Lesson 3 - Self assessment test

Multiple Choice

Circle the correct answer(s):

1. Predisaster environmental health measures are intended to reduce or eliminate environmental health hazard by:
   a. developing evacuation strategies, coordinating transport and distribution of emergency supplies, and developing a public education program
   b. developing an emergency operations plan, establishing an immunization program, and adopting routine measures to protect lifeline services
   c. developing a public education program, conducting epidemiologic surveys, and coordinating transport and stockpiling of emergency relief supplies
   d. developing an emergency operations action plan, adopting routine measures to protect lifeline services, and developing a public education program
   e. assigning key military personnel to special emergency relief teams, organizing an emergency administration, and developing an emergency operations action plan

2. To ensure safe delivery of water in the event of equipment failure at a water treatment plant, it may be expedient to:
   a. provide for bypass facilities to a point where raw water can be chlorinated
   b. conduct education campaigns to warn the public of possible contamination of water supplies
   c. monitor raw water on a more frequent basis prior to and during a disaster
   d. install auxiliary pipelines for delivery from the plant to private households
   e. all of the above

3. Preventive strategies in disaster management should focus on which environmental health impact area(s):
   a. power outage
   b. building structural damage
   c. food and water contamination
   d. water pipeline damage
   e. a, c and d only
   f. all of the above

4. Delivery of enough water and food to stricken areas is likely to depend largely upon:
   a. national and international cooperation in stockpiling and distributing relief supplies
   b. inspection and analysis of food and water supplies conducted by trained technicians
   c. financing efforts organized on a national scale to purchase necessary goods and treatment units
   d. protective and emergency measures taken to keep vital transportation routes open
   e. willingness of local people to eat and drink products that taste different than what they are used to

5. To be effective, a public education program should:
   a. persuade people to rely on government assistance
   b. persuade people to go immediately to centralized relocation camps in the event of a disaster
   c. inform people of emergency phone numbers to use in obtaining emergency information during and after a disaster
   d. inform people of what to expect and appropriate emergency steps to take
   e. enable communities to be totally self-reliant

6. Programs to educate environmental health services staff about emergency measures should be conducted:
   a. once it is known that a disaster is imminent
   b. at least once a year
   c. only for essential emergency personnel
   d. on a voluntary sign-up basis
   e. at least twice a year

7. To be able to plan effectively for protecting lifeline services and facilities before, during, and after a disaster, one should consider: *(select two)*
   a. a community's ability to pay for training programs and emergency drills
   b. the number of environmental health personnel in urban centers and their proximities to other disaster prone areas
   c. effects on environmental health services common to all disasters and effects associated with a specific disaster type unique to a particular area
   d. risk of disease in areas prone to disaster
   e. baseline environmental health levels

8. The primary cause of food or water contamination after a disaster is:
a. damage to civil engineering structures
b. interruption of inspection and monitoring activities
c. large-scale looting of public and private facilities
d. personnel shortages
e. difficulty in maintaining standards of personal hygiene

9. One way to reduce the chemical strength of contaminants in water is to:
a. provide for a reservoir storage capacity of 1½ to 2 times normal capacity
b. add sufficient quantities of water from a protected source to the contaminated supply
c. identify alternative sources of safe water
d. dilute the supply with floodwaters

10. A margin of safety for a particular service is achieved when:
a. the estimated capacity of that service after a disaster has occurred exceeds the minimum need for it in the population
b. manpower and resources allocated to that service prior to a disaster exceed the estimated requirements
c. multiple copies of maps, personnel and supplies lists, and descriptions of emergency procedures have been made
d. advanced preparations have been made to reinforce structures or provide for alternative sources
e. mutual aid agreements are drawn up among related services and shelter is guaranteed to essential environmental health personnel

11. Water treatment processes and equipment may shut down because of:
a. power outage
b. transportation failure
c. lack of field test kits
d. sudden reductions in water supply levels
e. contamination of water supplies

12. The first step in developing an environmental health emergency operations plan is to:
a. adopt routine measures to protect environmental health services
b. list all organizations that will participate in emergency activities and assign individual members to emergency teams
c. develop an emergency education and information program
d. inventory stockpiles of all equipment, supplies, and other materials necessary for the emergency
e. estimate the margin of safety between the capacities of services to meet requirements and the minimum estimated need for a service in the population

13. All relief workers should receive:
a. appropriate technical aids
b. appropriate antibiotics
c. first aid kits
d. copies of the emergency operations action plan
e. appropriate vaccinations

True/False

Indicate T or F:

___14. The principal objective of predisaster preventive environmental health measures is to eliminate or reduce hazards after a disaster event.

___15. Power outages are a common occurrence only during the initial impact of a disaster.

___16. In planning for power outages, on-site standby generators are always preferable to portable generators.

___17. Damage to reservoir retaining walls can cause serious injury or death to nearby individuals.

Answer Key
1. d
2. a
3. f
4. d
5. d
6. b
7. c,d
8. a
9. b
10. a
11. a
12. b
13. e
14. T
15. F
16. F
17. T

Lesson 4 –
Phase two: Measures taken during the disaster and in the aftermath

Study Guide
In this lesson the importance of advance planning is evident. It provides detailed information on how to carry out the Environmental Health Emergency Operations Plan during the warning period, as the disaster occurs, and in the immediate postdisaster emergency period. Finally, during the consolidation period, recovery measures begin.

Learning Objectives
- List the three time frames within phase two: during and immediately following a natural disaster.
- Understand the principal objectives that should be met during each time frame.
- Know ways to assure safe food, potable water, facilities for sanitation and hygiene, adequate shelter, and vector control during and immediately following a disaster.
- Be aware of the necessity of keeping the population fully informed during this period.
- Know the measures to be taken during the period of consolidation, as steps toward recovery begin.

Learning Activities
- Read pages 23-35 in the manual.
- Read pages 47-50 in the manual (Annex 2), particularly if you will be involved in provision of safe drinking water. Scan pages 51-55. This will be useful for detailed planning of environmental health measures during the immediate postdisaster emergency period.

Evaluation Complete the Self-Assessment Test.

Lesson 4 - Self Assessment Test

Multiple Choice

Circle the correct answer(s):

1. Activities taken during the emergency warning period include:
   a. testing of water for the presence of *Escherichia coli* and unsafe concentrations of nitrate
   b. providing safe, adequate shelter to stricken populations
   c. dusting of displaced persons to protect against spread of typhus
   d. mobilizing emergency personnel and informing threatened population of what to do
   e. preparing lists of needed assistance and submitting them to relief agencies

2. Food spoilage is commonly the result of:
   a. overcrowding
   b. power outage
   c. shortages of environmental personnel
   d. interruption of vector control activities

3. During the immediate postdisaster emergency period, ways to determine which areas merit greater attention include: *(select two)*
   a. sending out questionnaires to all stricken areas for distribution to and response from each household or displaced person
   b. conducting epidemiologic surveys of the incidence of disease
   c. checking population movements within or near stricken sites
   d. determining remaining stocks of all perishable foodstuffs
   e. surveying the availability of water, food, shelter, and waste disposal in stricken areas
   f. calculating the reserve capacities of retail and wholesale food outlets

4. The most essential item that disaster-stricken populations must be provided with is:
   a. nonperishable food
   b. medicine
   c. fuel
   d. drinking water
   e. adequate waste disposal
   f. shelter material

5. Latrine requirements in disaster operations include:
   a. 1 seat /20 persons in tent camps
   b. 1 seat /35 women in temporary building shelters
   c. 1 bore-holed trench /10 persons
   d. 1 shallow trench /200 persons
   e. none of the above

6. Large volumes of water that will be hauled to camps or to consumers in affected areas should be:
   a. cooled
   b. stored
   c. aerated
   d. strained
   e. disinfected
   f. heated

7. A____ is essential to the sanitary maintenance of latrines.
   a. sufficient supply of cleaning agents
   b. health education program in latrine Usage and upkeep
   c. survey of latrine construction projects
   d. sufficient quantity of water
   e. system of monitoring for the presence of nitrates

8. Overturning receptacles can prevent:
   a. damage to materials from constructing temporary shelters
   b. proper functioning of a refuse collection system
   c. proliferation of disease-carrying insects
   d. accumulation of foul-tasting water

9. In general, displaced persons should be encouraged and assisted to:
   a. evacuate to temporary resettlement camps
   b. stay with family, friends, or in nearby public buildings
   c. construct permanent settlements as far away as possible from the stricken area
   d. apply to aid organizations for tents and sleeping bags
   e. move to the nearest urban center

10. Tablets can be used to disinfect water following which guideline(s):
   a. the eight milligrams of elemental iodine released by the most common iodine tablet can treat 10 liters of water in one minute.
   b. water should be strained through layers of cloth or allowed to settle before disinfectant tablets are added

c. 160 milligram Halazone tablets can disinfect 40 liters of turbid water
d. all of the above

11. In relief operations. which of the following water requirements is *incorrect:*
a. 50 liters/person in field hospitals
b. 35 liters/person in washing installations
c. 25 liters/person in mass feeding centers
d. 5 liters/person in temporary camps
e. all of the above

12. Overcrowding can lead to disease principally because:
a. accessibility to medical care is severely curtailed
b. maintaining standards of personal hygiene becomes more difficult
c. water supplies are likely to become contaminated
d. lack of privacy, introduction of unfamiliar food, and mental stress all lead to a breakdown in the body's immune system
e. people generally take their pets and domestic livestock with them

13. In camps for displaced persons, it is important that residents be made aware of:
a. the camp's sanitation regulations
b. where to locate alternate sources of drinking water
c. names and titles of authorities to contact
d. how to disinfect their own water
e. timetables for returning to their homes

14. Emergency environmental health control measures are carried out:
a. during phase one of a disaster
b. as soon as a warning is received
c. after the rescue and accommodations of displaced persons
d. only by qualified environmental health specialists
e. in response to requests from officials in the stricken area

15. Water located near sewage outfalls, chemical plants, solid waste disposal fields and abandoned mines
a. should be boiled
b. should be disinfected before using
c. should be tested for the presence of *E. colli* and high concentrations of nitrates
d. should never be used
e. should not be used unless determined safe by a knowledgeable environmental health specialist
f. should be used only as a last resort

16. After mains, reservoirs, and wells have been repaired, they should be:
a. put back into service immediately
b. inspected by a qualified environmental health specialist
c. cleaned and disinfected
d. monitored daily for chlorine residuals

17. *Match* water requirements in different settings with the appropriate volumes:
___Minimum daily water capacity in temporary settlements and camps
___Daily consumption of water in field hospitals
___Minimum daily amount of water needed during evacuation in the tropics
a. 3 liters/person
b. 6 liters/person
c. 15 liters/person
d. 40-60 liters/person

18. Tank trucks are used for transporting
a. solid waste
b. drinking water
c. emergency personnel
d. equipment and supplies
e. gasoline
f. milk

19. Final disposal of solid waste in tent camps should be by:
a. waterproof and insectproof solid waste disposal containers
b. transport
c. incineration
d. treatment at a sewage treatment plant
e. burial
f. a or b
g. c or e
h. d or e

20. Covering food and water containers and removing all debris and garbage protects against:
a. pets and domestic livestock
b. contact with insecticides
c. fire hazard
d. disease vectors
e. spoilage

21. The first concern of decision makers during emergency periods is:

a. chemical contamination of food and water supplies
b. salt water contamination of food and water supplies
c. chlorine contamination of food and water supplies
d. heavy metal contamination of food and water supplies
e. microbial contamination of food and water supplies
f. vector contamination of food and water supplies

22. Precautions regarding the use of Halazone tablets in water disinfection include:

a. dosages for turbid and clear water are identical
b. before consumption, water should always stand one hour following disinfection
c. tablets come in two strengths with different tablet-to-water ratios
d. all of the above

True/False

Indicate T or F:

___23. All food should be inspected and analyzed in the immediate aftermath of a disaster.

___24. Priority should be given to the consumption of non-perishable food.

___25. When people are informed of what services are available, where to go and whom to contact, it improves the effectiveness of environmental health activities.

Answer Key		
1. d	9. b	18. c,d,b
2. b	10. b	19. b
3. c,e	11. d	20. g
4. d	12. b	21. d
5. e	13. a	22. e
6. e	14. b	23. c
7. b	15. e	24. F
8. c	16. c	25. F
	17.	26. T

Lesson 5 - Phase three: Rehabilitation measures

Study Guide
This final lesson deals primarily with short-term rehabilitation measures that should be started as soon as possible, such as restoration of lifeline environmental health services and restoration of essential surveillance activities. It also outlines the process for evaluating how well the emergency operations action plan worked.

Learning Objectives
- Understand the factors involved in planning for systematic restoration of environmental health services.
- List the six lifeline services that should receive the highest priority in short-term rehabilitation.
- Understand the purpose and application of technical health surveys in the rehabilitation phase.
- Consider when to take environmental health surveys, their order of importance, and basic parameters used for determining disease risk.
- Understand the importance of evaluating the emergency operations action plan, and consider the types of questions that should be posed and to whom a final report should be sent.

Learning Activities
Read pages 37-40 in the manual.

Evaluation
Complete the Self-Assessment Test.

Lesson 5 - Self-Assessment Test

Multiple Choice

Circle the correct answer(s):

1. What is the primary role of a national committee?
a. to mobilize and coordinate military and civil defense personnel in carrying out emergency relief efforts
b. to receive and distribute relief supplies obtained from national and international agencies
c. to plan, monitor, and coordinate the reconstruction and restoration of all lifeline services
d. to make policy changes at the national level for rechanneling appropriations into priority areas
e. to review and evaluate the emergency operations action plan so that strengths and weaknesses of the plan observed under disaster conditions can be recognized and improvements incorporated in preparedness planning for future disaster occurrences

2. Technical surveys are performed to:
a. train environmental specialists
b. let the people know that something is being done
c. assist officials in determining areas of priority intervention
d. test the usefulness of equipment and supplies
e. determine the incidence of disease

3. Environmental health surveillance activities are aimed principally at:
a. determining whether or not there is any increased risk of disease.
b. evaluating the emergency operations action plan
c. gathering information about specific equipment and supplies needed
d. contacting and reassuring victims that order will be restored
e. taking epidemiologic surveys of the incidence of disease

4. If water is found to contain *E. coli* and dramatically increased levels of chloride, this may indicate:
a. contamination of water by insect vectors
b. contamination of water by human waste
c. presence of a chlorine residual
d. a possible laxative effect on a consumer
e. high salt levels, rendering the water unfit to drink but acceptable as an ingredient in food

5. Besides testing the quality of the food itself, inspections should be made to determine the cleanliness of:
a. premises where food is handled and prepared
b. washing facilities
c. food storage facilities
d. facilities for sanitary excrete disposal
e. all of the above
f. none of the above

6. It is *especially* critical that settlements for displaced persons, hospitals, and schools be surveyed for:
a. food handling and preparation activities
b. children who have been separated from their parents
c. incidence of malaria and yellow fever
d. adequacy of clothing provisions
e. adequacy of solid and liquid waste handling systems

7. In order to better coordinate routine activities and improve emergency response as part of a future disaster preparedness plan, it is first necessary to:
a. create a national committee of all local and government service agencies
b. conduct technical and environmental health surveys
c. evaluate the emergency operations action plan as it was carried out before, during, and after a disaster
d. map all areas that were in greatest need of outside disaster relief
e. develop separate subplans for water supply service, solid waste service, and so forth

8. Environmental health surveys should begin:
a. as soon as water, food, and sanitation services have been restored
b. as soon as technical surveys have been initiated
c. throughout all phases of a disaster
d. as soon as electricity, transportation, and communications services are in operation
e. during the immediate postdisaster emergency period

9. Short-term rehabilitation measures are undertaken to achieve three primary objectives: *(select three)*

a. make emergency information available to the public
b. prepare lists of needed assistance and submit them to relief agencies
c. restore lifeline services
d. locate sites for tent camps
e. restore environmental health surveillance activities
f. conduct technical surveys
g. return hospitals, schools and churches back to a normal state
h. evaluate the emergency operations plan once it has been implemented

10. Phosphatase determination kits check for:

a. high levels of totally dissolved solids in drinking water supplies
b. deterioration in food quality
c. presence of disease vectors in food
d. presence of chlorine residual
e. milk quality
f. contamination of food or water with human waste

11. Chlorine residuals should be tested:

a. only where water is suspected of contamination by human or chemical waste
b. on a short-term basis
c. between the disaster occurrence period and the consolidation period
d. immediately after the disaster and on a routine basis thereafter
e. only until routine testing for *E. coli* and nitrates has been instituted

True/False

Indicate T or F:

___12. Only water used in the preparation of food should be tested for microbial and chemical contaminants.

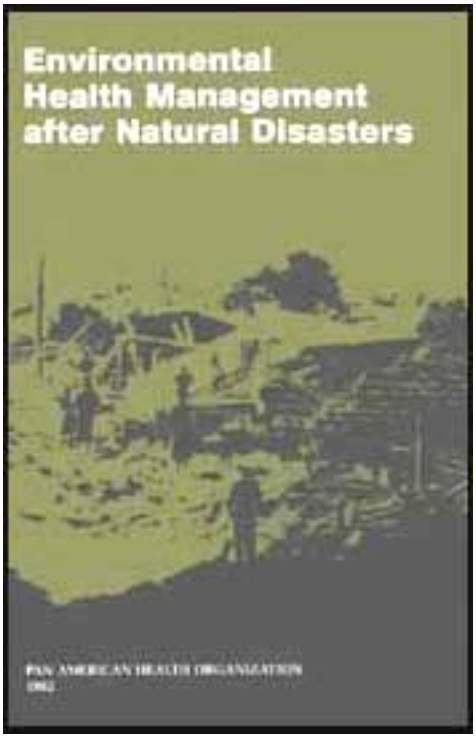
___13. Supplies and parts should be ordered from local sources only if they cannot be obtained from international relief agencies.

___14. Some rehabilitation measures must be taken during the emergency and immediate post emergency periods.

___15. Latrines should be inspected by qualified environmental health personnel during and after their construction.

___16. Heating fuel, communication, and electricity are not of primary concern during short-term rehabilitation.

Answer Key	
1.c	9. c,e,h
2.c	10. e
3.a	11. d
4.b	12. F
5.e	13. F
6.e	14. T
7.c	15. T
8.a	16. F



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HEALTH FOR ALL THE YEAR 2000

In 1977, the World Health Assembly decided that the main social target of the governments and of WHO should be the attainment by all people of the world by the year 2000 of a level of health that would permit them to lead a socially and economically productive life, that is, the goal popularly known as "health for all by the year 2000. "

In 1978 the International Conference on Primary Health Care (Alma-Ata, USSR) declared that, as a central function of the national health system and an integral part of economic and social development, primary health care was the key to achieving that goal. Subsequently, the governments committed themselves-at the global level at the World Health Assembly, and at the regional level at meetings of' the PA HO Governing Bodies-to implement the resolutions adopted for attaining health for all In the Americas the high point of these mandates was reached on 28 September 1981 when the Directing Council of PAHO approved the Plan of Action for implementing the regional strategies for health for all by the year 2000. These strategies had been approved by the Directing Council in 1980 (Resolution XX) and today constitute the basis of PAHO's policy and programming, and represent in addition the contribution of the Region of the Americas to the global strategies of WHO.

The Plan of Action approved by the Directing Council curtains the minimum goals and regional objectives, as well as the actions governments of the Americas and the Organization must take in order to attain health for all The Plan, continental in nature, is essentially dynamic and is addressed not only to current problems but also to' those likely to arise from the application of' the strategies and the fulfillment of regional goals and objectives. It also defines priority areas that will serve as a basis in developing the program and the necessary infrastructure, for national and international action

The exchange and dissemination of information constitutes one of the priority areas of the Plan of Action. PAHO's publication program-including periodicals, scientific publications, and official documents-is designed as a means of promoting the ideas contained in the Plan by disseminating data on policies, strategies, international cooperation programs, and progress achieved in collaboration with countries of the Americas in the process of attaining health for all by the year 2000.

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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 long-standing 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 diarrhea! 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 200O, 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 excrete, 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 response 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

This publication has been made possible by the dedicated work of Mr. Pierre Léger, who drafted the original manuscript. Mr. Léger, a civil engineer who also holds degrees in environmental and sanitary engineering, is Director of International Division of Medical Care Development, based in Washington. A native of Haiti, Mr. Léger, obtained his graduate degree from New York University and did his postgraduate work in the Netherlands. Thanks also are due to Mr. David Donaldson, formerly of the Pan American Health Organization, and to the Division of Environmental Health Protection of PAHO for their dedicated contribution to the conception and technical content of this manual.

Part I:
The effects of disaster on environmental health

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

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

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.

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

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

● Severe possible effect
o 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 diarrhea! 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 excrete 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 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.

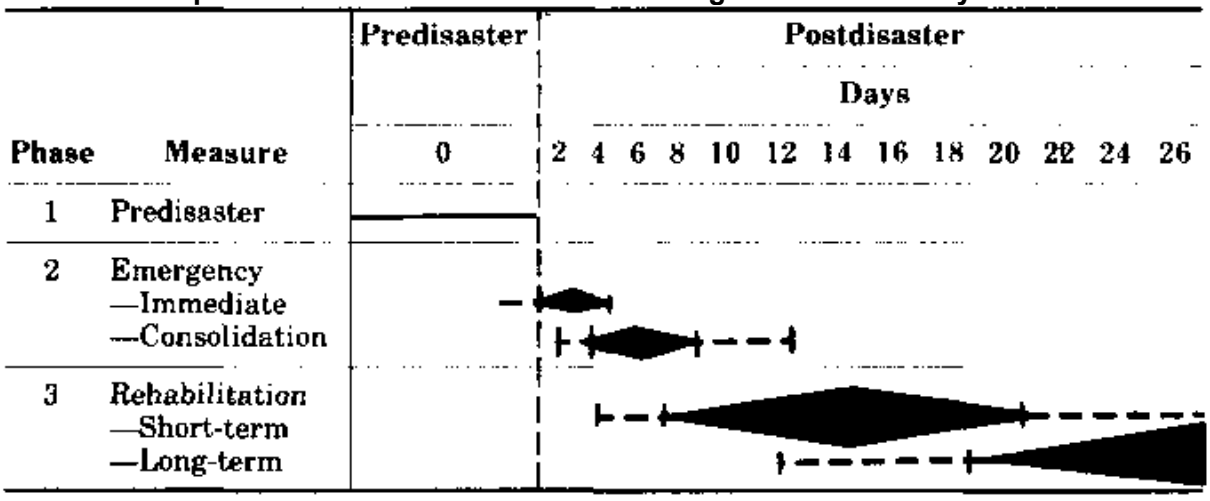
Phase One consists of measures undertaken before a disaster strikes in order to develop and maintain a state of preparedness. Preparedness planning focuses on areas of known high risk of natural disaster- areas with a history of occurrences, or areas that have been designated as sites of potential natural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

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



---- Anticipated duration of measure
- - - Possible extension of measure

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 excrete 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 wild 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 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.

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 moue 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 portability 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 orsanitarian) 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. Allrepaired 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 excrete 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 excrete 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 excrete 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 ho- 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.

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. 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, 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 excrete disposal. Testing of milk quality to determine 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.

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. Concerns 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 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 (KMnO4)

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 KMnO4 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:
56 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;
quaternary 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

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