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# GUIDE TO SANITATION IN NATURAL DISASTERS

M. ASSAR



WORLD HEALTH ORGANIZATION

GENEVA

1971

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## WORLD HEALTH ORGANIZATION

*The World Health Organization (WHO) is one of the specialized agencies in relationship with the United Nations. Through this organization, which came into being in 1948, the public health and medical professions of more than 120 countries exchange their knowledge and experience, and collaborate in an effort to achieve the highest possible level of health throughout the world. WHO is not concerned with problems that individual countries or territories can solve with their own resources. It deals, rather, with problems that can be satisfactorily solved only through the co-operation of all or several countries—for example, the eradication or control of malaria, bilharziasis, smallpox, and other communicable diseases, as well as some cardiovascular diseases and cancer. Progress towards better health throughout the world also demands international co-operation in many other activities : for example, setting up international standards for biological substances, for pesticides and for pesticide spraying equipment ; compiling an international pharmacopoeia ; drawing up and administering the International Health Regulations ; revising the international lists of diseases and causes of death ; assembling and disseminating epidemiological information ; recommending non-proprietary names for drugs ; and promoting the exchange of scientific knowledge. In many parts of the world, there is need for improvement in maternal and child health, nutrition, nursing, mental health, dental health, social and occupational health, environmental health, public health administration, professional education and training, and health education of the public. Thus a large share of the Organization's resources is devoted to giving assistance and advice in these fields and to making available—often through publications—the latest information on these subjects. Since 1958 an extensive international programme of collaborative research and research co-ordination has added substantially to the knowledge in many fields of medicine and public health. This programme is constantly developing and its many facets are reflected in WHO publications.*

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# GUIDE TO SANITATION IN NATURAL DISASTERS

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## PREFACE

*For some time the World Health Organization has been concerned about the lack of practical information and recommendations concerning environmental sanitation in emergencies and natural disasters. Hardly any systematic studies of the question have been made, and there are few countries where standing instructions have been issued on environmental sanitation under disaster conditions or where emergency sanitation supplies and equipment have been prepared and stockpiled.*

*When disasters occur, there is an urgent need for technical information on emergency procedures for water supply, disposal of excreta and other wastes, food and milk sanitation, disinfection and disinfestation, and the rapid control of flies, mosquitos, rats, and other insect and rodent pests. In the early stages of a disaster, much confusion and delay can be avoided if the staff in charge of sanitation relief know exactly what to do to remedy the most serious damage promptly and efficiently. It is clear that these needs cannot be met without careful planning and long preparation by the health authorities. Relief workers need to be given simple and practical instructions on how to perform their tasks under the abnormal and hazardous conditions created by a catastrophe.*

*As each disaster has its own characteristics, and as each country has varying means and resources at its disposal, it is impossible to recommend specific measures that are applicable to all emergencies everywhere. Nevertheless, certain elements of emergency sanitation are common to most natural disasters. This Guide provides basic information on the principles of emergency sanitation and contains detailed instructions for carrying out certain tasks. It is intended primarily to assist health authorities and relief agencies in developing their relief plans and in preparing themselves to cope efficiently with the sanitation problems caused by a disaster.*

*The author has long and outstanding experience in emergency sanitation practice; as Director-General of the Division of Sanitary Engineering in the Ministry of Health of Iran he was responsible for all environmental health relief to victims of floods and earthquakes. A first draft of this Guide was circulated to a number of experts in different parts of the world for their comments and suggestions, which have been taken into account in preparing the final text. A list of these reviewers will be found on page 7.*

*The League of Red Cross Societies—the world federation of national Red Cross Societies—has collaborated in this project since its inception.*

*The League's wide experience in the provision and co-ordination of emergency aid for victims of disasters, its assistance in obtaining documents issued by national Red Cross Societies, and its wise advice and sound recommendations have been extremely helpful in the preparation of this Guide.*

*The World Health Organization expresses its sincere gratitude to the League of Red Cross Societies, to the reviewers, and particularly to the author, Mr M. Assar.*

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## 1. INTRODUCTION

Despite the tremendous achievements of modern technology mankind remains virtually helpless in the face of such natural disasters as floods, hurricanes, volcanic eruptions, and earthquakes, which attack populated centres and cause much suffering, damage, and loss of life. The forces of nature recognize no rule or boundary; the best that man can do is to seek protection or to exercise vigilance and use the knowledge he has acquired to defend himself from these forces or alleviate their consequences.

The aftermath of natural disasters is no less serious than the immediate destruction they cause. After most catastrophes great numbers of people are left homeless, deprived of adequate food, clothing, and other essentials, and consequently exposed to adverse climatic conditions and to the spread of disease. It is the concern of other people, the state, and the world at large to save the lives of disaster-stricken people, protect their health, and help them return to normal life. Since health protection cannot be effective without the creation of a healthful environment, it is clear that one of the primary needs in disaster relief is the immediate provision of the best sanitary facilities and control that circumstances and available resources permit.

A natural disaster may occur at any time in any part of the world. A glance at the records of the League of Red Cross Societies and other relief associations, or even a review of the press in the last few years, suffices to show the diversity, frequency, severe consequences, and geographical distribution of natural catastrophes. Although the resulting problems vary widely in different parts of the world, disasters have many common features: one of them is confusion and panic. In the chaos produced by a disaster, even the professional sanitation personnel may be caught by surprise and may need to consult a guide on emergency sanitation measures before taking action to deal with the situation. The need for such a book is even more evident in view of the fact that qualified environmental health workers are scarce or non-existent in many countries and areas of the world and sanitation measures have to be carried out by unqualified persons.

In the majority of countries, no detailed study has been made of the question of environmental control under disaster conditions. Moreover, few health authorities have recognized the need to prepare lists of equipment and instructions for their use and to stock pile some of the basic sanitation supplies and equipment that will be required in an emergency.

The League of Red Cross Societies, the international body engaged in the co-ordination of relief work on a worldwide basis, has prepared publications on first aid and medical and nursing care in an emergency, and its *Disaster relief handbook*<sup>1</sup> deals briefly with some sanitation aspects of relief work.

At the request of governments confronted with severe natural disasters, WHO has on many occasions been able to provide urgent assistance and guidance. However, it has been felt that WHO could render a further service to governments by publishing a guide to the essential measures of environmental sanitation under disaster conditions.

The aims of this Guide are therefore:

(1) To draw the attention of health authorities and relief agencies to the need for planning and advance preparation to deal with the sanitation problems that arise in a disaster situation.

(2) To provide environmental health workers with a means of preparing themselves to deal with natural calamities. It may also be useful for reference in other emergencies.

(3) To serve as a basis for the preparation of similar documents, adapted to conditions in particular countries and written in the local languages, which individuals and private agencies could use for teaching the basic elements of emergency sanitation.

(4) As a consequence of achieving the above objectives, to minimize or eliminate the ill-health and misery that ensue from faulty environmental conditions.

(5) To formulate minimum acceptable standards of environmental health that can be applied when planning and carrying out emergency work under austere conditions.

The following considerations limit the scope of this Guide:

(1) It is intended to be of use in any part of the world, and therefore should be of a general character, providing guidance on the application of basic principles in the best available manner.

(2) Although it is hoped that the Guide will be of value for training, it is not designed as a training course or as a textbook.

(3) It is not the intention to present a package plan; this is not possible as each disaster has its own characteristics.

(4) The suggestions made are in the context of improvisation under emergency conditions. Essentially, the measures recommended are merely simplifications of environmental health measures appropriate in normal conditions and are neither exclusive nor exhaustive. The special knowledge and initiative of the individual will always be of major importance in emergencies.

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<sup>1</sup> League of Red Cross Societies (1970) *Red Cross disaster relief handbook*, Geneva.

(5) The procedures and standards laid down in this Guide relate only to emergency sanitation work, and not to rehabilitation work after the disaster. There is plenty of time to organize rehabilitation, and this is left to environmental health planners who should use their own judgement in setting requirements and sanitation standards that will form the basis of ordinary development work. What is expected of rehabilitation is quite different from what is expected of emergency relief.

(6) Exact specifications for equipment and supplies are not normally given, as this would conflict with the general character of the Guide. In any case, each country should make its own preparations in accordance with the resources available. In dealing with certain major topics, however, some detail has been deemed necessary.

(7) It is recognized that the most serious and widespread disaster situations are man-made. Wars impose the greatest limitations on personnel, equipment, supplies, and supporting services, and thus demand the most skilful use of relief resources. Although only natural disasters have been taken into account in the preparation of this Guide, much of the material presented could also be applied to man-made disasters and to epidemics.

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## 2. GENERAL CONSIDERATIONS

### **Definition of natural disasters and emergencies**

A natural disaster is essentially a change in environmental conditions followed by the disruption of normal ways of living and the exposure of the afflicted population to faulty and hazardous elements in the environment. It could be defined as follows:

A natural disaster is an act of nature of such magnitude as to create a catastrophic situation in which the day-to-day patterns of life are suddenly disrupted and people are plunged into helplessness and suffering, and, as a result, need food, clothing, shelter, medical and nursing care and other necessities of life, and protection against unfavourable environmental factors and conditions.

For the purposes of this Guide, an emergency is understood to be a situation created either by a natural disaster—in which man plays no causative role—or by a major accident, which may be caused unintentionally by man.

It would be impracticable to define an emergency on the basis of the population or area afflicted, but an emergency situation may be considered to exist when the normal local or national relief and public health service resources are not adequate, and emergency local, national or international resources must be called upon to cope with the situation.

### **Types of disaster and their results**

Disasters can be classified according to their source:

(1) *Meteorological disasters*: storms (hurricanes, tornadoes, cyclones, snowstorms), cold spells, heat waves, droughts (possibly resulting in famine), etc.

(2) *Topological disasters*: floods, avalanches, landslides, etc.

(3) *Telluric and tectonic disasters*: earthquakes, volcanic eruptions, etc.

(4) *Accidents*: failure of structures (dams, tunnels, buildings, mines, etc.), explosions, fires, collisions, shipwrecks, train crashes, poisons entering water supply systems, etc.

The magnitude of a disaster may be appraised by its effects:

(1) Loss of or damage to human and animal lives.

(2) Disruption of community services: electricity, gas and other fuels, communications, water supply, sewerage system, food supply, public health, etc.

(3) Destruction of or damage to private and public property.

(4) Spread of communicable diseases.

(5) Disruption of normal activities.

The following brief discussion of some of the more frequent disasters and their effects on the sanitation services and environmental conditions illustrates the need for emergency measures.

### *Storms*

Storms, known in different parts of the world as cyclones, hurricanes, typhoons, etc., may produce rotating wind currents with a velocity of 100–400 km/h and a displacement speed of 50–70 km/h. They are often accompanied by heavy rains and floods.

Cyclones originating in tropical oceans are especially destructive. They are most frequent during early summer and late autumn, and usually occur between 7 and 15 degrees of latitude on both sides of the equator. An average of 40 major cyclones per year are recorded within these zones.

In November 1970 East Pakistan was hit by a cyclone that caused the loss of hundreds of thousands of human lives and vast destruction of cattle and crops. In the south-eastern areas of the USA a single hurricane has caused damage amounting to several hundred million US dollars,<sup>1</sup> and in some years the total cost of natural disasters throughout the nation approaches one thousand million US dollars.

In addition to the primary damage caused by the force of the storm itself (unroofing houses, uprooting trees, etc.), extensive damage to human life and property also results from the flying debris. All sorts of materials are lifted up by storm winds and hurled about with great force. Storms damage power lines and poles, interrupting the operation of water and sewage treatment plants and pumping stations run by electricity. Refuse problems arise from the accumulation of debris that favours the propagation of flies and other vermin.

### *Cold spells*

Abnormally low temperatures can cause freezing of the ground to a considerable depth, as a result of which water and sewage pipes may burst. The blocking of water intakes and the icing of open reservoirs, tanks, and filters may cause operational difficulties. Problems are encountered in keeping a reasonable temperature within dwellings and in using outdoor installations.

<sup>1</sup> US Department of Defense (1964) *Hurricane Dora, 1964*, Washington, D.C.



### *Floods and tidal waves*

Most river floods result from excessive rainfall, melting snow, and ice jams. Certain rivers are known to flood regularly each year, and from past records the time and height of the rise in water level can be forecast. Unpredictable flash floods are caused by abnormal torrential rains on bare, wet or frozen ground, the rapid run-off producing raging torrents in river beds that are normally low or dry.

Some floods are caused by the overtopping or failure of dams and dikes or by tidal waves. In a tidal wave, a great mass of sea-water, as much as 6–9 m high, can inundate vast areas up to 80–100 km inland. Most tidal waves are produced by submarine earthquakes, but a few result from storms. Sanitary installations in coastal areas are exposed to destruction by the incoming breakers and to erosion and land subsidence.

Flood damage results from the inundation of land and from the destructive force of flood waters. Floods can displace water and sewage lines; in one instance a 5-km length of 90-cm water main was washed away.<sup>1</sup> Water treatment plants and pumping stations may be inundated and the fine silt that may enter the pumps, motors and other equipment causes expensive and time-consuming repairs. Damage to the protective structures of wells and springs may allow contamination by flood water. Sewer outlets and sewage treatment plants are most exposed to flooding: the back-flow in flooded sewers causes the overflowing of manholes, septic tanks and cesspools. The dispersion of all sorts of refuse by the rising waters constitutes a serious problem of clearance and removal. Accumulated debris favours the propagation of flies and rodents. Burial of the dead and disposal of animal carcasses becomes urgent and sometimes difficult.<sup>2</sup>

Paradoxically, fire is a hazard closely connected with floods. Rising waters may upturn oil or gasoline tanks or invade fuel reservoirs, and spread their contents over wide areas; if these fuels ignite the spread of fire is quite rapid, for floating debris and other objects usually provide ample combustible material. Short-circuiting of the electrical system of inundated buildings may cause fire or electrocution.

### *Earthquakes*

An earthquake is a convulsion of the earth's crust produced by explosions deep inside the earth (plutonic), by the activity of volcanoes (volcanic), or by sliding movements of the layers of the earth's crust along faults (tectonic).

Tectonic earthquakes are the most common and destructive. The grating and rubbing of the material along the sides of a fault starts the

<sup>1</sup> Tetzlaff, F., Lauster, K. C. & Mark, R. S. (1956) *Publ. Hlth Rep. (Wash.)*, 71, 814.

<sup>2</sup> See US Department of Agriculture (1964) *First aid for flooded homes and farms*, Washington, D.C. (Agriculture Handbook No. 38).

convulsion tremors that spread widely towards the surface. Major earthquakes are usually accompanied by foreshocks and aftershocks of varying intensity.

Earthquakes, in addition to destroying buildings and structures, may cause avalanches, rockslides, cracks and cleavages, land uplift and subsidence, mud spouts, damming of rivers, tidal waves, and fires. Damages and hazards directly related to sanitation, which result from the earthquake itself, include the breakage, distortion, and displacement of water and sewage lines; structural damage to water and sewage treatment plants and pumping stations; the cracking of dams and reservoirs, leading to water leakage or contamination; the accumulation of debris, collapsed buildings, and the entanglement or burial of dead bodies and animal carcasses in the ruins; the fracture of septic tanks and cesspools; and the contamination of water wells when the protective casing is disjoined.

#### *Volcanic eruptions*

Molten lava pouring from the crater of an erupting volcano and rolling down the mountainside may engulf whole towns and villages in its path. Sometimes sulfurous fumes, earth tremors and showers of volcanic ash accompany the eruption.

Sanitation problems created by volcanic eruptions, other than those related to the care of refugees, are the destruction by molten lava of water supply structures and the pollution of air by ash and sulfurous fumes for a considerable distance.

#### *Fires*

Fire is a major destructive agent that accompanies many natural disasters and accidents. Fires that follow floods, earthquakes, explosions and other disasters, generally cause more devastation than the initial catastrophe. One of the most outstanding characteristics of a fire is its ability to spread rapidly. Some of the causes of rapid fire-spread in buildings are design and structural deficiencies, overcrowding, use of highly inflammable materials, inadequate fire protection, delay in giving the alarm, inadequate water supply, and strong winds.

The main effect of fire on sanitary installations is the heavy demand for water. To satisfy this demand, adequate provisions should be incorporated into the design of the whole water supply system (capacity of treatment plants, pumping, storage, distribution network, etc.).

#### *Explosions*

The principal causes of accidental explosions are carelessness, high temperature, a sudden blow, or a combination of heat and shock. Explosions are often followed by fires. Methane gas produced by excessive decomposition of stagnant or slow-moving sewage may explode and burn

along the sewers, causing widespread fires. Water and sewer mains in the vicinity of the explosion may break, and plumbing within buildings may be damaged. Debris produced by explosions can raise serious problems. Explosions in sewage and water treatment plants may create emergencies.

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### 3. EMERGENCY ACTION

#### **Pre-disaster measures**

The predictability and frequency of disasters determine the scope and extent of pre-disaster measures and the provision of personnel, materials and services. Careful advance planning always pays great dividends, and can alleviate many of the grave consequences of natural disasters. An adequate warning system, for example, can prevent great loss of human life, for it makes it possible to move people to a safe place in good time. Pre-disaster planning should be geared to the full use of existing resources, and should therefore involve many government departments, municipal and local bodies, relief work agencies, and the public. The responsibilities and interrelationships of these various bodies are discussed in section 4. Accident prevention and safety engineering are beyond the scope of this guide, but some precautionary and protective measures that can be taken in preparation for a disaster are suggested below.

#### *Storms*

- (1) use of deep-rooted trees as natural windbreaks;
- (2) design and construction of buildings, using suitable materials with adequate braces, so that the walls are fixed securely to the foundations and roof;
- (3) avoidance of building sites close to a waterfront;
- (4) maintenance of structures in a condition compatible with design strength, or demolition of old and dilapidated structures that are beyond repair;
- (5) guarding against erosion of areas subject to inundation;
- (6) sandbagging of vulnerable waterfronts;
- (7) covering of window panes;
- (8) collection and safe storage of loose materials, tools and light equipment;
- (9) pruning trees, and felling those that might be dangerous;
- (10) provision of adequate water storage and water-piping capacity for fire-fighting.

*Floods and tidal waves*

- (1) construction of dams to hold back flood waters;
- (2) construction of earth embankments, dikes, and concrete or masonry walls;
- (3) dredging of river channels to facilitate rapid run-off.

*Earthquakes*

- (1) provision of adequate open space around buildings;
- (2) ensuring that foundations are well-tied together, and that the walls are securely fixed to the foundations and roof, using adequate braces;
- (3) use of good building materials and good workmanship;
- (4) avoidance of superfluous decorations and overhangs;
- (5) study of buildings that have survived previous earthquakes.

*Accidents and fires*

- (1) use of fireproof materials and safety equipment in mines, factories, stores of inflammable or explosive materials, etc.;
- (2) proper maintenance of structures, equipment, etc.;
- (3) provision of fire-fighting equipment and adequate water supply;
- (4) training of personnel in safety practices.

*Warning and alert*

Many natural disasters are related to meteorological conditions. Knowledge of the weather is extremely important in planning and carrying out the proper evasive or protective action. A network of meteorological stations suitably located in storm-prone areas, connected by telephone and wireless to an assessment centre, helps greatly in the forecasting of storms. Weather stations should have standby power generators. Modern technology has produced effective equipment for weather forecasting, such as cyclone-tracking radar, wind-finding radar, and automatic photographic transmission. The latter gives a picture of the cloud cover within a radius of 1600 km of the station. Earth-orbiting satellites can also be helpful, but can provide a picture only at the moment they pass over a certain spot. Shore-based cyclone-tracking radar can furnish a continuous series of photographs revealing the direction and speed of storms. Hurricane-hunting from aircraft that fly into the eye of storms is practised by the US Weather Bureau over the Caribbean Sea, with very effective results.

Volcanoes often give warning signs before they actually erupt, and earthquakes have foreshocks that are sometimes felt or detected. With the advancement of seismology and the improvement of seismometers it is possible to forecast earthquakes within the known seismic belts, though as yet only to a limited extent. Meteorology, hydrology, and electronic flood warning equipment help to forecast an approaching storm or flood at least a few hours in advance, thus allowing evasive action to be taken.

An essential part of any warning system is that information should reach the people living in dangerous areas in good time. An effective and integrated communication plan should be established for diffusing such information. The availability of transistor radios makes it possible to mount a workable alert operation. Besides the press, telephone, radio and television, there are a number of improvised means of alerting the general public to danger: (a) coloured flags (usually red); (b) high-power transistorized megaphones (operating on flashlight batteries); (c) sirens (hand- or power-operated); (d) rockets; (e) signal flares and pistols; (f) drum-beating and smoke signals; (g) explosives; (h) red strips or flares dropped from aircraft; and (i) lanterns (operating on batteries).

Usually a combination of several means is employed, according to circumstances and availability of equipment. A sufficient number of alert posts should be established in each area where disaster threatens. Local authorities, community leaders, and volunteers can contribute to making the alert system effective. Preparatory training and practices in each locality are essential: however, false alarms have a very undesirable effect on the public, who should therefore be notified in advance of any training exercise.

When disaster is impending, the alert operation should be accompanied by the mobilization of the public at full strength and speed. Adequate mobilization demands previous planning and preparedness. People need instructions before, during and after an alert system is put into operation; times, frequency and terminology should have been worked out in advance.

### *Evacuation*

Evacuation consists of transferring people from their homes to a safe place outside the area threatened by a disaster. Timely evacuation is an effective way of reducing the loss of human life, and needs the organized effort of the entire community. Pre-disaster planning should include the selection of the nearest safe sites to which people can be evacuated. Because of the difficulties and hardships involved in evacuation, however, and because people are often reluctant to leave their homes unless they actually feel the threat of the catastrophe, the population should be shown convincing evidence that disaster is impending.

People on the march and in their new temporary quarters will be in need of food, clothing, shelter, medical care, and the minimum sanitary facilities.<sup>1</sup>

### *Education of the public*

It is important to ensure that the general public know how to take emergency sanitation measures if a natural disaster should damage water supply and sewage installations. Especially in areas subject to natural

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<sup>1</sup> US Department of Health, Education, and Welfare (1956) *An outline guide covering sanitation aspects of mass evacuation*, Washington, D. C. (Public Health Service Publication No. 498).

disasters, it will be helpful to organize courses in emergency sanitation or to distribute leaflets containing emergency sanitation instructions to every home. The text of such leaflets should be clear, non-technical, and liberally illustrated. A specimen text is reproduced in Annex 1.

### **Disaster measures**

The active period of a disaster may vary from a few seconds (earthquakes) to several days (floods), and the measures applicable during this period vary accordingly. They may include: (a) evacuation; (b) the rescue of injured and stranded people; (c) attention to the injured (first aid and medical care); (d) recovery and disposal of human and animal corpses; and (e) fire-fighting.

### **Post-disaster measures**

During the period from the end of the disaster itself to the end of relief work (which should be followed as soon as possible by rehabilitation), the following action should be taken: (a) continued rescue and care of victims; (b) restoration of communications; (c) relief (i.e., provision of temporary shelter, food, medical care, and public health, environmental control and welfare services); (d) survey, report, and evaluation of damage; and (e) emergency repairs. Most of the environmental health measures contained in this Guide are applicable during this post-disaster period.

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## 4. PLANNING AND ADMINISTRATION OF ENVIRONMENTAL HEALTH ACTIVITIES

The technical ability to solve environmental health problems raised by natural disasters is only one aspect of the work. The effective application of such technical knowledge under difficult conditions requires advance planning and co-ordination with other activities in the area stricken by the disaster, so that full use can be made of available resources.

Immediately after a natural disaster the public health team—comprising at least a public health doctor or physician, a sanitary engineer or sanitarian, a nurse, a laboratory technologist, and other allied staff—should launch a comprehensive public health programme. Active case-finding and reporting of infectious diseases, immunization and other prophylactic measures, diagnostic services and chemotherapy, first aid and surgical operations, nursing services and environmental health work, all help to protect or restore the health of the afflicted population. All public health resources should be deployed to prevent the outbreak of communicable diseases and to alleviate suffering. However, it is beyond the scope of this Guide to cover all these aspects of public health work.

### **Co-ordination**

Often, sanitation personnel will have to rely on the general relief work administration for communications, transport, equipment and supplies. Consequently, the importance of establishing an effective plan for co-ordinating all the services engaged in relief work requires a brief explanation.

Unplanned or improvised co-ordination of the many activities involved in an emergency causes a series of difficulties in applying relief action. The chaos and overlapping of efforts that often occur at such times can largely be avoided by proper preparations. In countries stricken by repeated disasters, a central authority should be appointed to assume over-all responsibility for relief operations and to co-ordinate activities, make policy decisions, and enforce them expeditiously. This body should be given full powers to establish priorities, cut through red tape and act quickly; if it is to operate effectively, its director will need a dynamic personality and strong leadership ability. The over-all responsibility for relief work is entrusted in some countries to the civil defence organization, in others to a national relief committee constituted by legislation. The type and structure of this co-ordinating body depend on the political system and



customs of the individual country. However relief is organized, specific assignments should be allotted to different governmental departments and welfare agencies. It is essential to organize relief committees at all levels, i.e., national, provincial, and local.

The inclusion of a senior sanitary engineer in the central relief authority not only ensures better environmental control but also saves effort and money. It should be his responsibility to draw up an effective plan for the co-ordination of sanitation operations within the over-all relief scheme. The relationship of environmental health services with other agencies engaged in relief work is discussed in Annex 2.

### **Planning**

The importance of advance planning for disasters cannot be over-emphasized.<sup>1</sup> Any disaster is capable of disrupting the ordinary life of people, disorganizing public services and affairs, and causing physical damage. Goodwill and concern for other people are not enough to avert the grave consequences that natural disasters usually impose upon people. Experience has shown that errors are committed when there are no proper organization, no trained people to act according to a previously arranged plan, and no efficient direction, co-ordination and control of the relief operation. These errors lead to confusion, delay, oversights, misuse and duplication, and make it more difficult for the responsible authorities to mobilize all the available resources fully and in good time.

The United Nations and the League of Red Cross Societies have given high priority to planning for disasters. The League has offered its services to governments and national Red Cross societies for the preparation of national plans for disaster relief operations, and a manual issued by the United Nations in 1966 contained the following statement:

The United Nations, in co-operation with the League of Red Cross Societies, is prepared to offer assistance in pre-disaster planning, such as in the formulation of pre-disaster plans, organization of inventories of technical equipment, services and supplies which could be mobilized at the time of disaster, revision of building codes, etc. Requests for such assistance presented through the Resident Representative of the United Nations Development Programme will be considered in the normal way with due consideration being given to the priorities attached to such requests by the requesting Governments within their country programmes, by substitution of projects or through the use of operational savings.<sup>2</sup>

The assistance provided by international organizations is discussed in detail in Annex 3.

The preparation of a disaster manual or relief handbook is one of the

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<sup>1</sup> See Kubryk, D. (1963) *Canad. J. publ. Hlth*, 54, 403; and Larsen, A. A. (1963) *Canad. J. publ. Hlth*, 54, 410.

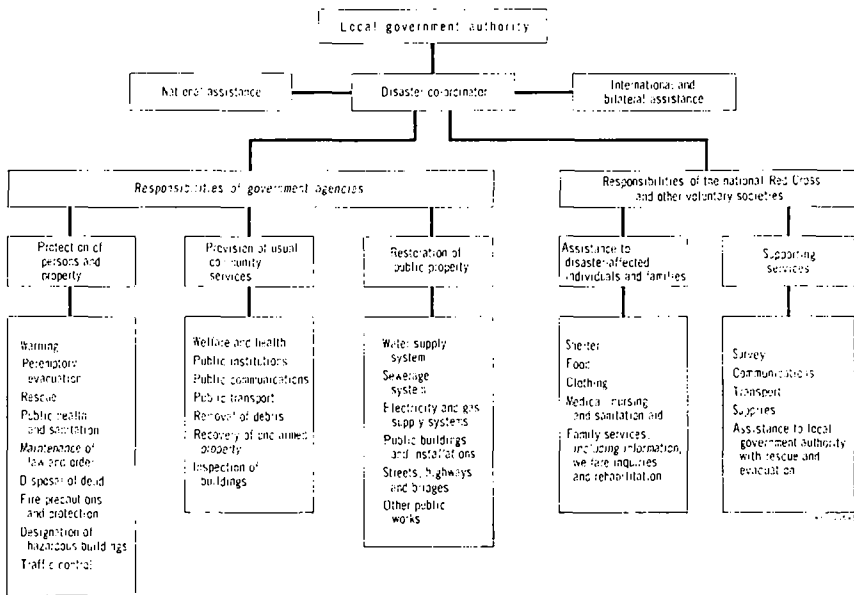
<sup>2</sup> United Nations, Secretariat of the Administrative Committee on Co-ordination (1966) *International action in cases of natural disaster: a manual on the resources and procedures of the United Nations family*, New York (mimeographed document).

tasks that should be carried out during the planning period. Schemes for insurance or compensation in respect of losses resulting from a disaster should also be planned and instituted.

Pre-disaster planning is in fact the preparation in advance by the government of a relief plan. It defines the responsibilities entrusted to each of the bodies involved in relief operations: army, police, public services, civil defence, Red Cross, private organizations, etc. Responsibilities are distributed according to the individual character, the specialized field, and the personnel and material resources of each agency. Provision should also be made in the plan for the effective co-ordination of the delegated activities. A chart showing the general responsibilities in natural disasters is presented in Fig. 1.

The disaster plan may extend to the rehabilitation phase, if this responsibility has been entrusted to the same national body. This would be advantageous, because many relief activities could be geared to rehabilitation, so saving money and effort.

FIG. 1. RESPONSIBILITIES IN NATURAL DISASTERS<sup>a</sup>



<sup>a</sup> Adapted from: US Public Health Service (1961) *Health mobilization course manual*, Washington, D.C., Department of Health, Education and Welfare.

In all aspects of the over-all plan, including environmental health operations, the question of logistics is of capital importance.

The national relief body should draw up an operations plan for a general type of emergency, since the exact details of the emergency to be

faced are usually unknown. Full knowledge of the plan and of the basic concepts of operation is essential to the conduct of activities during an emergency: it enables the responsible officers to carry out co-ordinated work towards a common objective without delay and overlapping. The scope of the plan depends on the emergencies expected, the number of people at risk, the extent of the affected area, and the frequency of emergencies. Arbitrarily, the operations plan may be based on provision for 10 000 persons and on distribution of the necessary supplies and equipment so that they can be pooled in the area of the disaster within 48 hours.

The operations plan should define (a) objectives; (b) command and control structure; (c) limits of authority and responsibility; (d) duties and lines of communication; (e) channels for requesting and supplying additional resources; and (f) details of operation.

Each service involved in relief operations, including the environmental health service, should develop its own operations plan based on the general principles already described. The operations plan for emergency sanitation should include:

- (1) effective liaison with other health departments and the relief organization;
- (2) inspection, identification, and evaluation of sanitation problems;
- (3) immediate mobilization of personnel and equipment;
- (4) emergency action to control or eliminate environmental health hazards;
- (5) emergency restoration of water supply, wastes disposal services, etc.;
- (6) evaluation of damage to public sanitary installations and provision of advice on remedial measures;
- (7) report on conditions and on measures applied.

### Organization

In emergencies, organization is directed to the adaptation of government and welfare units and their resources to meet the needs of the situation. Organization charts show diagrammatically the chain of command and areas of responsibility; specimen charts for the organization of (a) relief work in general, (b) public health, and (c) environmental sanitation are shown in Fig. 2-4.

The relief committee should be headed by the high commissioner appointed by the government; its members should include the directors of services and representatives of army staff and of welfare societies and other national or international agencies concerned with relief work.

Two important aspects of organization that should be borne in mind are:

- (1) *Span of control*: efficient supervision and control at all levels can be exerted only when the labour force is grouped in small teams of 5-7 persons under a supervisor.

(2) *Operational area*: each team or operational disaster unit should serve in a specified area. If the region affected by the disaster is divided into operational areas and each of these is assigned to a working unit, this contributes tremendously to the smooth running of operations.

FIG. 2. SPECIMEN ORGANIZATION CHART FOR RELIEF WORK IN GENERAL

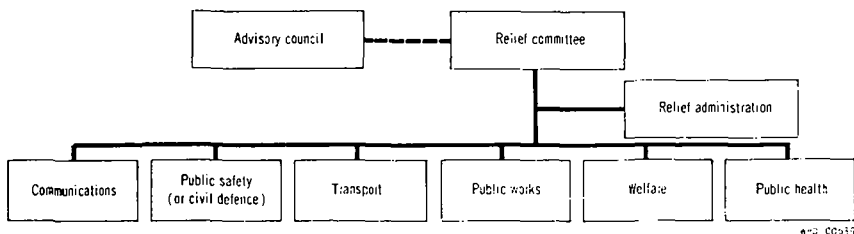


FIG. 3. SPECIMEN ORGANIZATION CHART FOR RELIEF WORK IN PUBLIC HEALTH

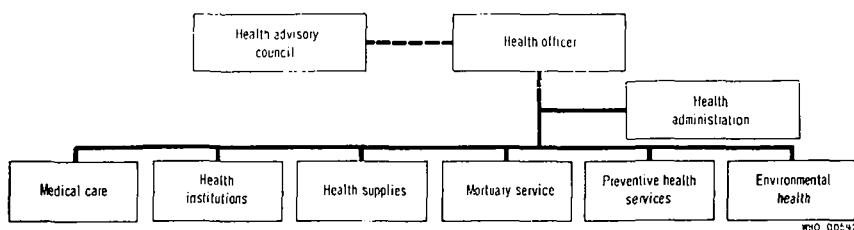
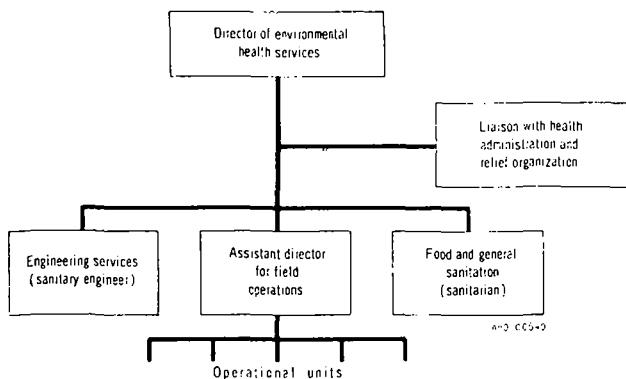


FIG. 4. SPECIMEN ORGANIZATION CHART FOR RELIEF WORK IN ENVIRONMENTAL SANITATION



The sources of funds for disaster relief are as follows:

(1) *Ordinary funds (current budget)* : part of the expenses can be charged to the current budget; savings may be made available for emergency operations.

(2) *Emergency funds* : there may be an emergency fund at the disposal of the government at all times, or a specific sum of money may be approved after disaster occurs.

(3) *Non-governmental sources* : welfare societies (e.g., the Red Cross), charity organizations, and clubs.

(4) *Donations for disaster relief* : a bank or post office account may be opened to collect individual contributions.

(5) *Bilateral and multilateral sources* : governments may have bilateral or multilateral agreements with other nations to provide assistance in case of national emergencies.

(6) *International sources* : the United Nations and its specialized agencies have made provisions for assistance in emergencies; these are described in Annex 3.

(7) *Individual donations from governments* : in the case of national emergencies, other governments frequently make donations for the relief and rehabilitation of the afflicted people.

It is advisable to pool all financial resources and put them at the disposal of the body in charge of national relief.

## **Personnel**

### *Type of personnel*

Professional sanitary engineers are needed at policy-making levels, for technical services, surveys, over-all planning and supervision. Professional sanitarians are needed to assist the sanitary engineers in making surveys; in the control of water quality, food sanitation, and wastes disposal installations; and in vermin control, supervision of the work of auxiliary sanitation personnel, etc. Auxiliary sanitation personnel are needed to look after all sanitary installations, food sanitation, vermin control operations, disinfection, supervision of workers and volunteers, health education, etc. These auxiliaries should have received formal education in the main aspects of environmental sanitation, since they will have to carry out the bulk of the field work. If the emergency is too extensive and the number of professional environmental health workers is not adequate, the manpower may be supplemented by sanitarians working in industry, consulting civil and sanitary engineers, dairy personnel, private laboratory personnel, industrial housekeeping personnel, railway and airline sanitation personnel, water company personnel, pest-control operators, teaching staff of universities and institutes in the fields of sanitary sciences and sanitary engineering,

science students, etc. These individuals should receive orientation instruction and should work under public health engineers.

### *Number of personnel*

The number of environmental health personnel needed in an emergency depends on the nature of the community, the number of people affected, the extent of the area affected, the type of services required, the effectiveness of transport and communications, the training and efficiency of available personnel, etc. The figures presented in Table 1 are based on the experience of the author.

TABLE 1. NUMBER OF ENVIRONMENTAL HEALTH PERSONNEL NEEDED IN AN EMERGENCY

Population affected	Number of personnel		
	Sanitary engineers	Sanitarians	Auxiliaries
Less than 1000	—	1	1-2
1000-10 000	—	1	2-5
10 000-50 000	1	2	5-10
50 000-100 000	1-2	2-3	10-15
For each additional 100 000	1	2	10

### *Training*

It is not the purpose here to discuss the educational requirements of environmental health workers, but rather to stress the need for training in special fields and for organizing courses and exercises in emergency field work from time to time. Fighting against the consequences of a disaster can be compared with war: preparation and peacetime manoeuvres are necessary to keep personnel ready to face emergency situations. In addition, some sanitarians may receive specialized training in vermin control, disposal of wastes, mortuary service, food sanitation in mass feeding centres, field hospital sanitation, and similar subjects. Sanitary engineers working in public health may be given practical training in the emergency operation and maintenance of water and sewage plants and systems. The training courses for emergency action must be practical, with the minimum theoretical work. Demonstrations and exercises should be arranged so as to use the equipment and supplies stockpiled for emergencies.

A detailed manual of environmental health procedures in emergencies, designed to meet local needs and to make the best use of local resources and facilities, will be of great assistance in the training of personnel.<sup>1</sup>

<sup>1</sup> See, for example: Canada, Department of National Health and Welfare (1967) *Environmental health in disaster*, Ottawa; and Macdonald, F. W. & Trygg, J. E. (1968) *Environmental health practices in disasters*, Washington, D.C., US Department of Health, Education, and Welfare.

### *Use of volunteers*

It is useful to train young members of welfare societies (e.g., the Junior Red Cross), scouts, and members of mountaineering and sports clubs in emergency sanitation. Volunteers may also be drawn from industry and elsewhere. It is possible to use young males for sanitation work, giving them on-the-job training for specific activities. Volunteers can always relieve professionals of some of their tasks, and this possibility of augmenting the efficiency of the available staff should never be overlooked. However, volunteers must always work under professional supervision.

### **Equipment and supplies**

It is essential that a comprehensive list of equipment and supplies for use in emergencies be prepared in co-operation with other services. Obviously, there is no need for the environmental health division to stock all the items itself. The important point is that provision is made for their speedy transport and immediate availability where they are needed. Natural disasters leave no time for urgent requisitioning and purchasing, which in many countries are subject to complicated rules and regulations. Heavy equipment is usually very expensive, and need not be stored; it is usually available from the army or from the highway or public works departments. Certain supplies, such as kitchen utensils, temporary shelters, etc., may be the concern of welfare agencies. The sanitary requirements for these supplies could be discussed with other agencies involved in relief work. A list of necessary chemical supplies, pipes, fittings and jointing materials, tools for a mobile repair unit, spare pumps and power units, trucks, tanks, and many other items may be prepared in collaboration with the officials in charge of water and sewage works. Follow-up is necessary to ensure that the equipment and supplies needed for the emergency operation of water and sewage systems are purchased and stocked properly for speedy delivery and use. In large-scale emergencies, it may be necessary to draw material from every possible source. It is important to ensure that the equipment and supplies stored for emergency use conform to standard specifications, so that the disaster-afflicted community can benefit from the resources of other communities.

A list of equipment and supplies required for emergency sanitation work for 10 000 people is given in Annex 4. The items on this list may be stockpiled by the environmental health service or other agencies, but they should be available to the sanitation personnel at all times. Some of the equipment and supplies may be distributed to different regions of a country. If so, plans should be made for their rapid transfer in case of a major emergency.

It is recommended that inventories be reviewed frequently by environmental health officials to keep them up to date. Periodic tests must be

made to ensure that the equipment is always in working condition. These same supplies should be used for training and exercise purposes. Some items of equipment may be used in routine environmental sanitation operations and need not be stockpiled, but there should always be an adequate reserve of supplies.

Equipment that might be required by a sanitarian working in a disaster area is listed in Annex 5.

### **Transport**

Field vehicles of the jeep or Land Rover type, trucks, boats, and planes are very useful in mobilizing men, equipment, and supplies. Vehicles enable the most efficient use to be made of the available technical staff and thus reduce the number of personnel needed. Moreover, an important factor in emergency work is speed and this can only be obtained by the use of adequate vehicles. It is recommended that engineers and sanitarians in planning and supervisory positions be provided with sufficient transport. Professional auxiliaries who have to work in more than one area also need transport. Trucks should be made available for prompt delivery of equipment and supplies. The number of vehicles needed depends on many factors. Roughly speaking, five vehicles of the jeep or Land Rover type, two  $\frac{3}{4}$ -ton trucks and one 3-4-ton truck would suffice for sanitation operations for 100 000 people. Boats and planes may become necessary and should be obtained through the relief organization.

### **Living quarters and food supply for relief personnel**

Emergency relief imposes long working hours, and sometimes workers spend 14-16 hours a day in adverse environmental conditions for a considerable period. This hard work can exhaust the strongest person after a few days, and proper rest and food are needed to compensate for the loss of energy. In most areas afflicted by disaster food soon becomes scarce. The relief personnel must be properly looked after so that they can continue working efficiently: they should be provided with adequate living quarters where they can rest, wash, and eat one hot meal each day.

It is recommended that the environmental health division make provisions for its own personnel. To depend on welfare agencies for food and shelter is unwise and unfair, as these agencies will already have more than enough to do to provide victims with shelter and food. Consequently, tents, stoves, cooking utensils, lamps, water containers, blankets, sleeping bags, chairs and tables, packaged rations, and other camping equipment should be included in the supplies stored for use in emergencies.



**Rules and regulations**

Sanitary rules and regulations designed for normal conditions are not easy to apply in emergencies: they are too elaborate and detailed for such situations. Simple and brief regulations, tailored to the requirements of the actual situation and adapted to the existing possibilities, should therefore be worked out by supervisors and made known to the general public. This is a matter of applying basic principles to the improvised installations, and success depends to a great extent on the ingenuity, training and experience of the supervisory environmental health personnel. Once realistic regulations are laid down they should be strictly observed.

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## 5. ENVIRONMENTAL HEALTH MEASURES \*

### Search, rescue and evacuation

During the first few hours or sometimes days after a disaster, the immediate task is to search for and rescue people who are injured, old, disabled, or for any other reason unable to escape from dangerous positions. Fire control, the removal of debris to permit entry, the recovery of dead bodies, etc., are tasks connected with search and rescue. The situation may demand that sanitation personnel take part in such activities, although usually the rescue work is handled by the fire brigade, police, army, etc. Rescue and evacuation often take place simultaneously, and this demands intensive efforts from everyone involved. To assist in rescue and evacuation, environmental health personnel should be familiar with the communications and transport systems of the disaster area. While searching for people, every precaution must be taken to avoid both worsening the condition of the victim and endangering the safety of the rescuer.

There are very few sanitary measures that can be taken while people are being moved to temporary quarters and the journey should therefore be as short as possible. Vehicles should be provided for at least the elderly and disabled, but most people will have to walk to the evacuation site.

They should be told to take along as much food, water, and clothing as they will need. However, in many instances this will not be possible, especially when the journey is long, and food and water should be provided, preferably at fixed stations along the route. The relief or welfare authorities should be advised that during this transitional period only unperishable foods that do not require cooking should be distributed. Water may be distributed by tankers at a minimum rate of 3 litres per person per day in temperate regions, rising to at least 6 litres per person per day in hot desert areas. When distribution of water by tankers is not possible, people should be instructed to boil whatever water they find *en route*: the distribution of chlorine or iodine tablets for water disinfection is another possibility. It is very difficult to ensure sanitary excreta disposal while people are on the march, and not much can be done about refuse collection. At rest points, however, sanitation squads should bury excreta and solid wastes in holes or trenches at least 60 cm deep. After use, the hole or trench

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\* The main recommendations given in this section are summarized in Annex 6.

should be filled in with the excavated earth and trampled on. It may also be necessary to control body vermin by the application of insecticides.

### **Shelter**

After most disasters, people need to be provided with temporary shelter; people in rural areas may want to take their livestock with them, and provision must be made for dealing with the resulting sanitation problems. There have been occasions when a nearby unafflicted community or an undamaged part of a city has been able to shelter stricken people. Provision of shelter is the responsibility of relief and welfare authorities. The canvas tent is the most convenient and common type of emergency shelter. Aluminium prefabricated shelters have also been used in some countries for semi-permanent camps. Recreational camp sites near the city or place of disaster frequently offer adequate conditions, as they normally have certain sanitary installations. The chief environmental health officer has the responsibility of seeing that the following points are observed when evacuees have to be accommodated for more than a few days.

#### *Tent camps*

(1) The site should be away from mosquito breeding-places and garbage dumps. It should have good access to roads.

(2) The topography of the land should permit easy drainage; the sub-soil and ground water conditions should also be studied. Land covered with grass will prevent dust, but bushes and excessive vegetation that can harbour insects, rodents, reptiles, etc., should be avoided or cleared.

(3) Wherever possible, the area should be naturally protected from adverse weather conditions; narrow valleys and ravines subject to floods should be avoided.

(4) Areas adjacent to commercial and industrial zones, exposed to noise, odours, air pollution, traffic jams, and other nuisances, should also be avoided.

(5) There should be ample space for the people to be sheltered and for all the necessary public facilities. Roughly speaking, this means 3–4 hectares for every 1000 people (30–40 m<sup>2</sup> per person).

(6) The site should be within reasonable distance of a good and ample source of water.

(7) The tents should be arranged in rows on both sides of a road at least 10 m wide to permit easy traffic. Between the edge of the road and the tent pegs there should be at least 2 m.

(8) Inside the tent there should be a minimum floor area of 3 m<sup>2</sup> per person.

(9) There should be a minimum distance of 8 m between tents, so that people can pass freely without being obstructed by pegs and ropes. This spacing also provides a safety measure against the spread of fire.

(10) Small tents for a small number of occupants are preferable. This point should be taken into consideration when planning for emergencies.

(11) The residential area of the camp should face the prevailing wind.

(12) In cold weather kerosene stoves or other heating appliances should be provided, and people should be instructed in their use; every precaution should be taken to prevent fires and explosions.

(13) Natural ventilation is adequate for the tents.

(14) Wind-proof kerosene or oil lamps should be provided for lighting tents and roads. Lanterns with electric bulbs and dry batteries may also be provided.

(15) Where there is no piped water, water tanks should be installed on both sides of the road. The tanks should have a capacity of 200 litres or more, depending on the frequency of refill, and should be so spaced that camp dwellers need not walk more than 100 m to draw water; several taps fixed to each tank may ease distribution. It is advisable to put the water tanks on wooden stands of a convenient height.

(16) Garbage collection cans (capacity 50–100 litres) with tightly-fitting lids should be provided for every 4–8 tents (25–50 persons);

(17) Privies or other types of excreta disposal installation should be located in blocks behind the tents (see page 64).

(18) One double-sided ablution bench (3 m long) should be provided for every 50 persons.

(19) Drainage ditches should be dug round the tents and along the sides of roads. Water supply points should also have adequate drainage to avoid mud and sludge.

(20) When camp sites are in use for long periods, the surface of roads should be sprinkled with oil to keep dust down.

(21) Sanitation regulations should be laid down according to what is feasible in the particular situation and should be strictly observed.

(22) The camp should be divided into two separate areas: a residential area and a community service area (mass feeding centre, field hospital, recreation, etc.).

(23) For better management and control of communicable diseases, large camps should be avoided, or subdivided into independent units of no more than 1000 people.

(24) The camp site should be cleaned regularly according to a pre-arranged schedule.

### *Buildings*

If emergency shelter is provided within existing buildings, more attention should be given to ventilation and the removal of odours. The amount of

fresh air needed is 30 m<sup>3</sup> per person per hour. It may be necessary to provide mechanical ventilation. A temperature of 20°C is desirable, but lower temperatures can be tolerated with warm clothing. The following points should be taken into consideration in relation to buildings used for shelter:

(1) People sleeping on beds or mats should have a minimum floor area of 3.5 m<sup>2</sup> or 10 m<sup>3</sup> of air space. In rooms with high ceilings double bunks may be used.

(2) A minimum distance of 0.75 m should separate beds or mats.

(3) Emergency exits and fire escapes should be provided; the flues of stoves used for space heating should extend outside the building; overloading of electrical circuits should be avoided; lanterns and lamps should be so placed or suspended as to eliminate dangers; kerosene and gasoline should be stored outside buildings; clear instructions on fire hazards and safety practices should be displayed in conspicuous places; fire-fighting equipment should be properly maintained.

(4) One wash basin should be provided for every 10 persons, or 4–5 m of wash bench for every 100 persons; there should be separate benches for men and women, and waste receptacles at each bench. One shower head is needed for every 50 persons in temperate climates and one for every 30 persons in hot climates. Floors must be disinfected daily.

(5) For human waste disposal water-flushed toilets should be provided if possible (see also page 64). Latrines should be located within 50 m of the building but away from the kitchen or dining hall.

(6) One garbage can of 50–100 litres capacity, with a tightly fitting lid, should be provided for every 12–25 persons.

### **Water supply**

Provision of a safe and adequate supply of water is essential, and it is the responsibility of the sanitary engineer or the sanitarian involved in emergency relief work to make certain that such a supply is available and readily accessible. The bacteriological, chemical, and physical condition of water for human consumption should comply with established standards.<sup>1</sup>

#### *Requirements*

Water needs during evacuation and on the march have already been discussed (see p. 33). The following figures are intended as a guide in calculating minimum water requirements for drinking, cooking, and basic cleanliness.

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<sup>1</sup> See *International standards for drinking-water*, 2nd ed., Geneva, World Health Organization, 1963.

- (1) Field hospitals and first aid stations: 40–60 litres per person per day.
- (2) Mass feeding centres: 20–30 litres per person per day.
- (3) Temporary shelters and camps: 15–20 litres per person per day.

Unless there are severe limitations on the supply of safe water, no restrictions should be placed on its use. If there is a shortage of water, rationing, close supervision of consumption, and other water conservation measures should be practised. As soon as the early days of emergency have passed and the water supply has been increased restrictions should be lifted, since there is a correlation between water consumption and cleanliness on the one hand, and between cleanliness and the incidence of diseases on the other. With no restrictions the use of water may approach 100 litres per person per day.

### *Investigation and selection of source*

A thorough search should be made for all the possible sources of water within reasonable distance of the camp. The importance of an investigation and sanitary survey of the available sources cannot be overemphasized: treatment operations adopted under emergency situations are at best only improvisations of the conventional methods of water purification, and it is clearly of the utmost importance to select the sources that are least exposed to contamination.

The possible sources of water are discussed below:

#### *1. Municipal system*

If the disaster has affected the water supply system of a city or town, top priority should be given to putting the system back into operation.<sup>1</sup> Damaged mains and feeders should be repaired as fast as practicable. It is often possible to by-pass a damaged section by closing certain valves and to restore the water service in the major part of the distribution system. New methods for the quick coupling and plastic patching of pipes have been developed so that repairs can be made in the shortest possible time. This work, however, requires advance planning by the water authorities: the procurement of the necessary equipment and supplies and the training of technicians for emergency operations. The maintenance of good records and maps, proper operation of the system, and the stocking of spare parts are essential preparatory measures. The questionnaire in Annex 7 will help waterworks superintendents assess how well prepared their plant is to meet emergencies.

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<sup>1</sup> See Canada, Department of National Health and Welfare (1965) *Emergency water services and environmental sanitation*, Ottawa.

Following disasters the water pressure should be raised and the chlorine concentration should be increased so as to protect the distribution system from polluted water that may enter the pipes, especially after floods. If the water treatment plant or pumping stations are flooded, the flood water should be pumped out and floors and equipment cleaned and disinfected. After any repair on the distribution system the repaired main should be flushed and disinfected with a chlorine solution of 50 mg/litre for a contact period of 24 hours, after which the main is emptied and flushed again with potable water. If the demand for water is urgent, or the repaired main cannot be isolated, the concentration of the disinfecting solution may be increased to 100 mg/litre and the contact period reduced to 1 hour. At the end of disinfection operations, but before the main is put back into service, samples should be taken for bacteriological analysis and determination of chlorine residue. More detailed information on the disinfection of water mains is provided in Annex 8.

When a water treatment plant, pumping station, or distribution system is so badly damaged that operation cannot be restored for some time, other methods described in the following paragraphs must be used.

### *2. Private systems*

There are often some private water supply systems in the vicinity of a disaster-stricken community. These systems may belong to dairies, breweries, food and beverage plants, and other industrial or agricultural establishments. The source of supply is often a deep well or a private treatment plant. Water from these sources, with adequate chlorination as necessary, can be connected to a distribution system or hauled to the points of consumption. Owners are usually ready to co-operate and the possibility of using such supplies should never be overlooked in investigating the sources of water in an area.

### *3. Springs and wells*

Ground water can often be found in the vicinity of a disaster area. It is less subject to gross contamination than surface waters. Ground water originating from deep aquifers (such as is obtained from deep wells and certain springs) will be free from contamination if certain simple protective measures have been taken. Another great advantage of ground water is that it is clear and may need no treatment other than disinfection. Springs are simpler to exploit, as no pumping is needed to bring the water to the surface.

When springs are used as a source of water supply for a disaster area, careful attention must be paid to geological formations. Limestone and certain rocks are liable to have holes and cracks, especially after an earthquake, that may lead to the contamination of ground water. Springs are also exposed to contamination from flood waters. Proper location and

well-built protective structures are therefore necessary to safeguard ground water quality.

The development and protection of springs and wells can be effected *within a short time*, provided that construction materials, tools, and skilled workers are available. It is possible, depending on the geological conditions of the area, to sink different types of wells—dug, bored, driven, jetted, and drilled—to provide a dependable source of water that can be used in the rehabilitation phase as well.

A sanitary survey of the area surrounding a well site or spring is of the utmost importance. This survey, which should be carried out by a qualified professional environmental health worker, should provide information on sources of contamination, geological structures (with particular reference to overlying soil and rock formations), quality and quantity of ground water, direction of flow, etc.

The well should be at least 30 m from any potential source of contamination, and should be located higher than all such sources. The upper portion of the well must be protected by an external impervious casing extending at least 3 m below and 30 cm above ground level. The casing should be surrounded by a concrete platform at least 1 m wide that slopes to allow drainage away from the well; it should connect to a drain that will carry the spilled water away. The opening for drop pipes should be sealed to prevent outside water from entering the well. The rim of manholes should project at least 8 cm above the surrounding surface, and the manhole cover must overlap this rim.

Immediately after construction or repair, the well should be disinfected. First the casing or lining should be washed and scrubbed with strong chlorine solution containing 100 mg of available chlorine per litre. A stronger solution is then added to produce a concentration of 50–100 mg/litre in the water stored in the well. After adequate agitation, the well water is left to stand for at least 12 hours, then pumped out. The well is then allowed to refill. When the residual chlorine of the water drops below 1 mg/litre the water may be used.

Most of what is stated above applies also to the location and protection of springs. The following points may be added:

(1) The collection installation should be so built as to prevent the entrance of light.

(2) The overflow should be so located as to prevent the entrance of surface water at times of heavy rainfall.

(3) The manhole cover and gates should be locked.

(4) Before using the water, the collection chamber should be disinfected with a chlorine solution.

(5) An area within a radius of 50 m around the spring should be fenced off to prevent ground surface contamination.



Detailed information of the development and protection of water supplies is given in a monograph published by WHO in 1959.<sup>1</sup> Fig. 5-10 are reproduced from this book to illustrate protective measures for wells and springs.

#### 4. Surface waters

Surface water should be used as a source of water supply only as a last resort. Malodorous, highly coloured, or highly polluted waters should be avoided. Water from surface sources should be disinfected and if possible treated to remove turbidity, colour, and impurities. If the usual purification equipment is not available, improvisation is necessary. Prior to treatment, an infiltration gallery or several well-points connected to a manifold, located on the bank of a stream, could reduce turbidity and the number of bacteria in the water. Measures should be taken to protect the watershed from pollution by animals and people. As it is usually difficult to enforce control regulations, the point of intake for water supply should be located above any tributary carrying grossly contaminated water. The pump intake should be screened and placed so that it will not take in mud from the stream bed or floating debris. The device can be something extremely simple, such as a perforated drum fixed in the middle of the stream.

#### Treatment

Treatment should be improvised according to the materials and equipment available and the impurity of the water. The treatment may take various forms:

##### 1. Disinfection

The purpose of disinfection is to kill pathogenic organisms and thereby prevent water-borne diseases. The disinfection of water can be accomplished by boiling or by chemical treatment. Chlorine and chlorine-liberating compounds are the most common disinfectants. Chlorine compounds for water disinfection are usually available in 3 forms:

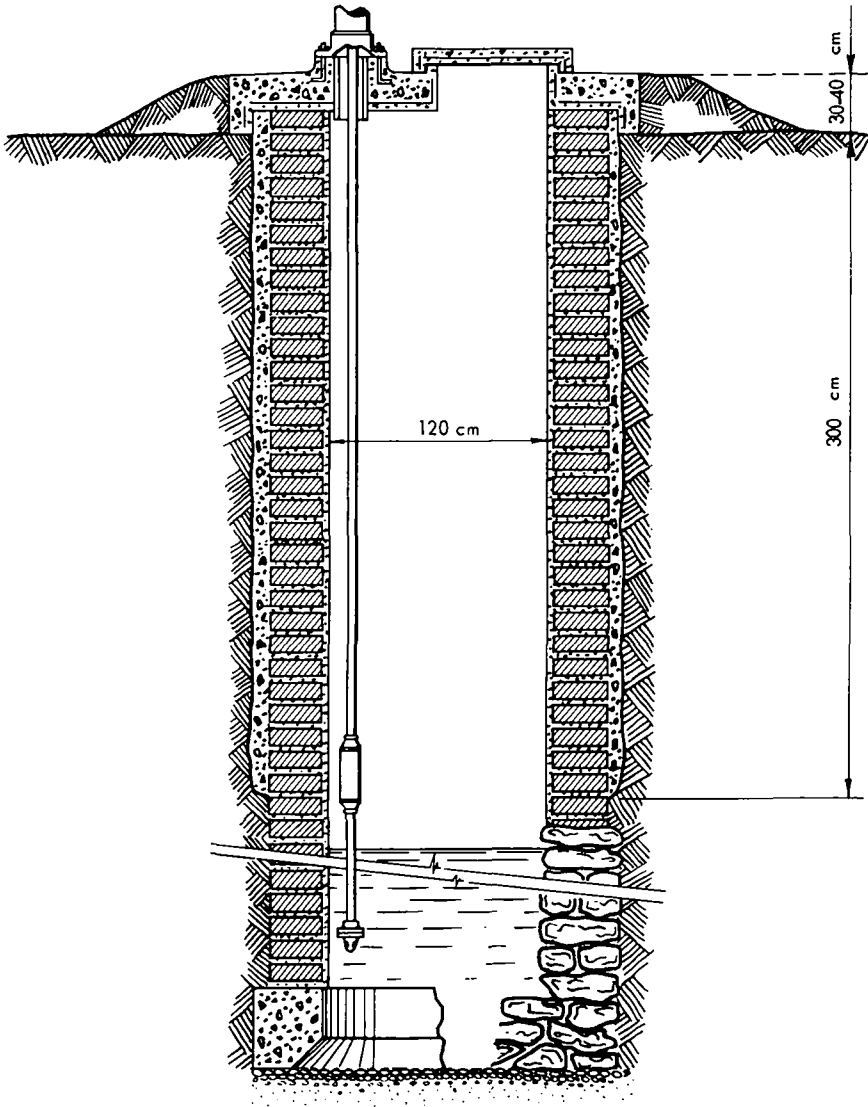
(1) Chlorinated lime or bleaching powder, which has 25 % by weight of available chlorine when fresh. This is an unstable compound that loses its chlorine rather quickly, especially when stored in humid and warm places. Its strength should always be checked before use.

(2) Calcium hypochlorite, a more stable compound sold under various proprietary names. This compound contains 70 % by weight of available chlorine. If properly stored in tight containers and in a dark cool place, it preserves its chlorine content for a considerable period.

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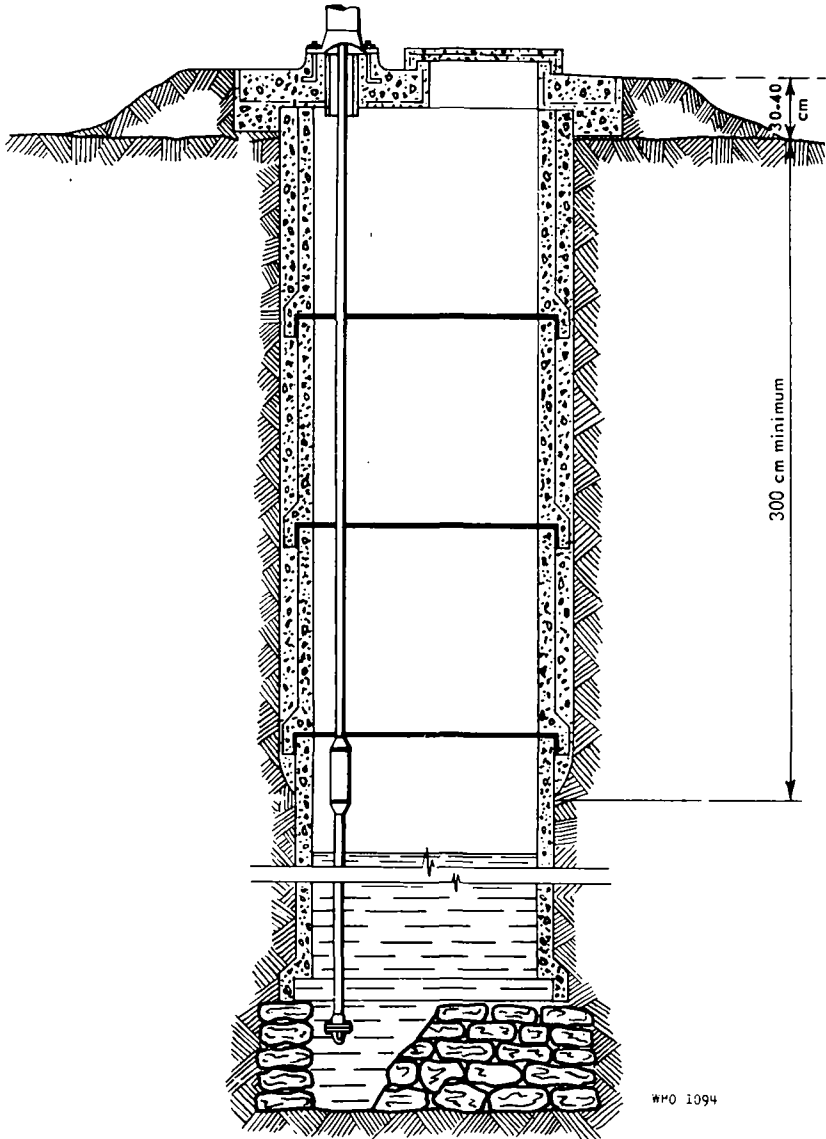
<sup>1</sup> Wagner, E. G. & Lanoix, J. N. (1959) *Water supply for rural areas and small communities*, Geneva (World Health Organization : Monograph Series, No. 42).

FIG. 5. DUG WELL WITH PROTECTIVE CASING AND PLATFORM



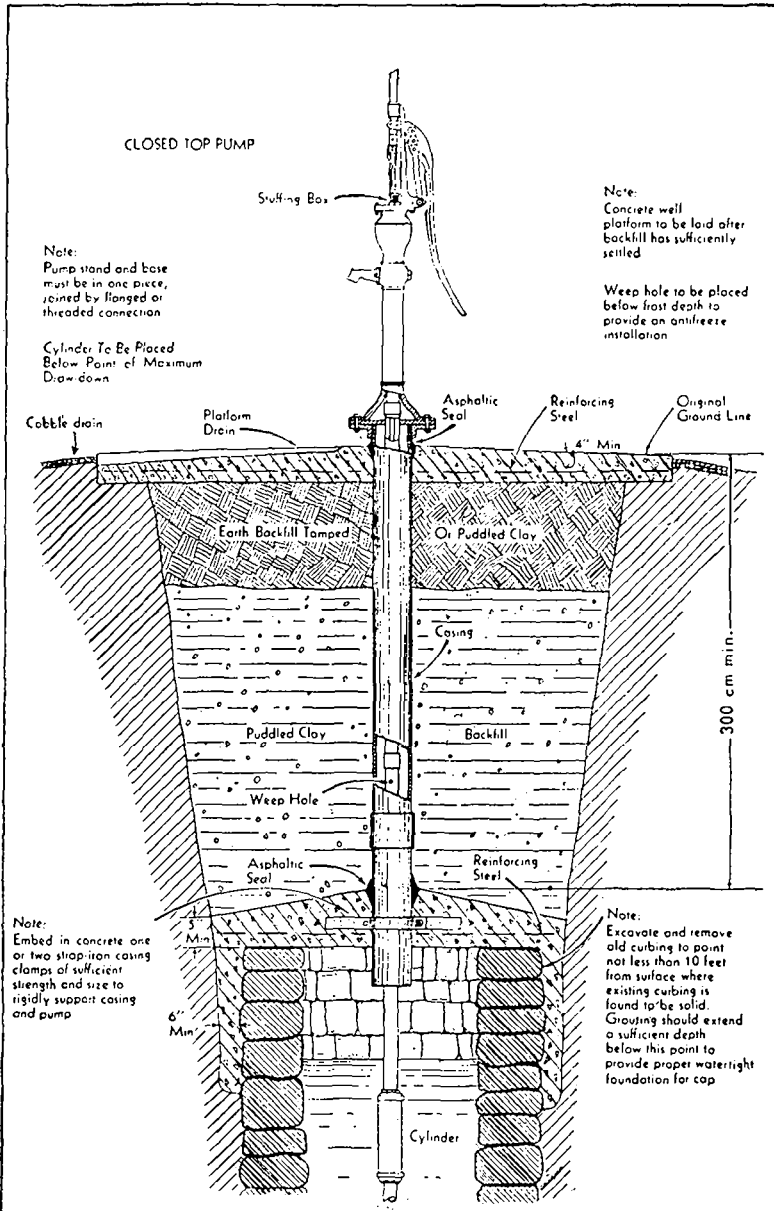
This figure shows a dug well and an outside protective cover of concrete. At the well bottom are two different types of construction; one, built-up, round stones offering a filter wall, and the other, a concrete shoe. Stones must be laid up after the well is completely excavated, and are practical only in areas of coarse sand and gravel. The concrete shoe is employed where the well casing is sunk as the excavation progresses, and is usually more practical in fine sand. A protective, graded sand filter should be built up in the bottom of this well.

FIG. 6. DUG WELL LINED WITH CONCRETE OR CLAY TILE



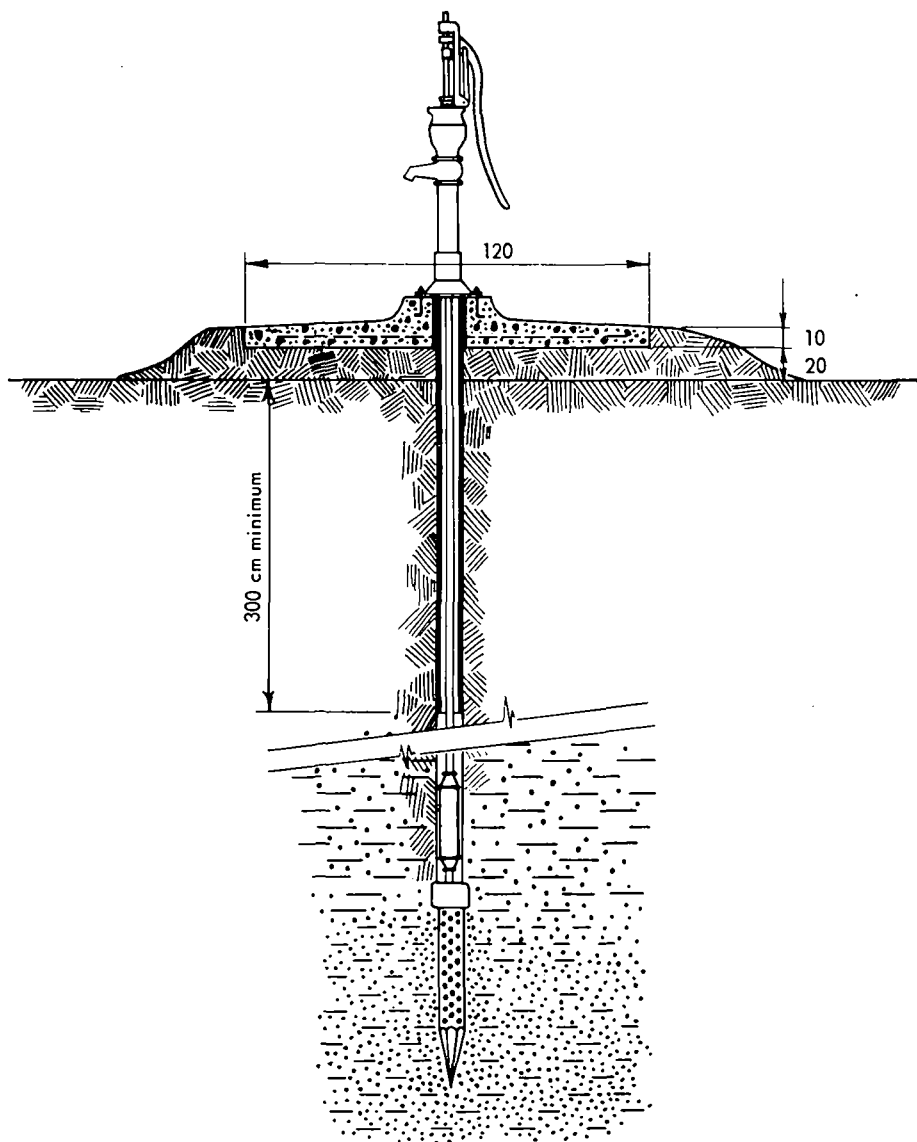
Concrete or clay tiles make excellent well casing and can be placed quickly and easily into the well by the use of a simple A-frame or other temporary structure for lowering tile into a well. Note the outside, protective layer of concrete which extends down to at least 3 m (10 ft) to ensure water-tightness of the upper walls.

FIG. 7. RECONSTRUCTED DUG WELL WITH BURIED SLAB



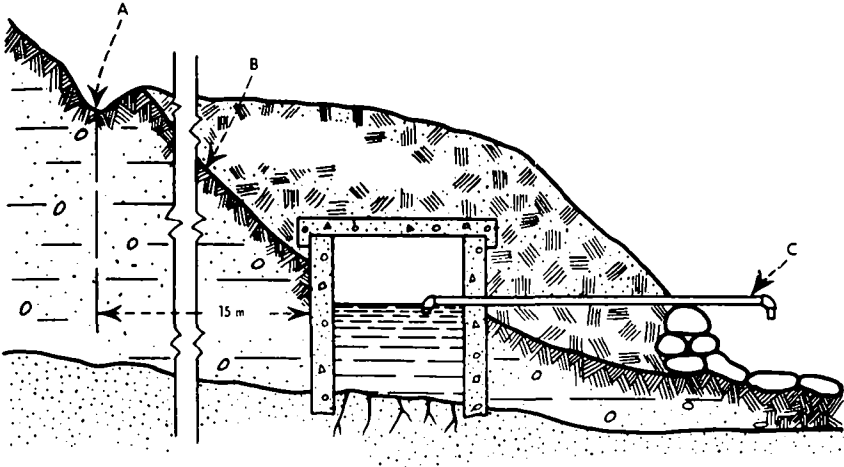
Reproduced from US Public Health Service, Joint Committee on Rural Sanitation (1950) *Individual water supply systems*, Washington, p. 25.

FIG. 8. DRIVEN WELL WITH DROP-PIPE AND CYLINDER AND PROTECTIVE PLATFORM



In areas with relatively coarse sand, driven wells can be an excellent and very cheap means of obtaining water. They can be driven rapidly and put into operation quickly. With proper technique, this well can be developed to increase its capacity. Note the water-tight casing which extends down to a minimum of 3 m (10 ft) below ground surface.

FIG. 9. PROPERLY PROTECTED SPRING (I)



RHO 5243

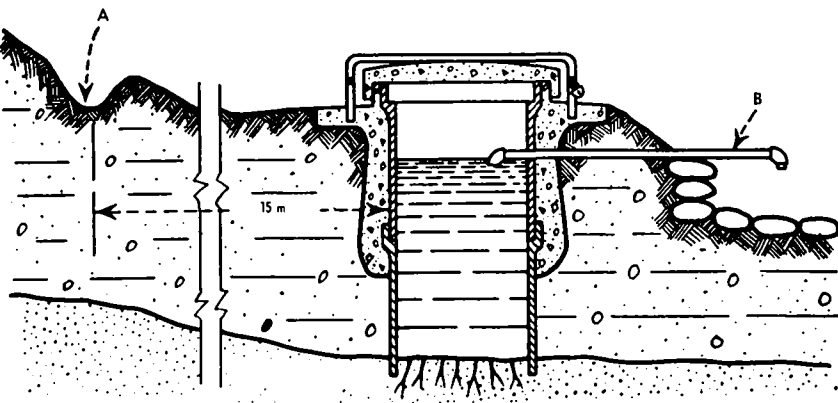
A = Protective drainage ditch to keep drainage water a safe distance from spring

B = Original slope and ground line

C = Screened outlet pipe: can discharge freely or be piped to village or residence

Springs can offer an economical and safe source of water. A thorough search should be made for signs of ground-water outcropping. Springs that can be piped to the user by gravity offer an excellent solution. Rainfall variation may influence the yield, so dry-weather flow should be checked.

FIG. 10. PROPERLY PROTECTED SPRING (II)



RHO 5244

A = Protective drainage ditch to keep drainage water a safe distance from spring

B = Screened outlet pipe: to discharge freely or be piped to village or residence

(3) Sodium hypochlorite, usually sold as a solution of approximately 5% strength under a variety of proprietary names. Its use in water disinfection is limited to small quantities under special circumstances.

Chlorine and iodine tablets are also available, or the water can be boiled, but the use of these methods is limited to small quantities of water intended exclusively for drinking purposes. Other commonly available materials suitable for emergency disinfection of water include Lugol's solution (5% available  $I_2$ ), tincture of iodine (2% available  $I_2$ ) and various iodophor compounds.

Factors affecting chlorination include:

(1) Chlorine demand. Some of the chlorine added to the water reacts with organic matter and other reducing substances and is lost for disinfection; this "chlorine demand" can be determined experimentally. A "chlorine residual" for disinfection should be added in excess of the demand to ensure that the specified concentration is available. Thus the chlorine required for disinfection is the sum of the "chlorine demand" and the "chlorine residual".

(2) Contact time and concentration. Adequate mixing and contact time is needed to produce maximum disinfection. Generally speaking, the higher the concentration the shorter the time required for disinfection. With ordinary doses of chlorine a minimum contact time of 30 minutes should be maintained.

(3) Temperature. The effectiveness of chlorine is reduced as the temperature of water decreases.

(4) Hydrogen-ion concentration. The disinfecting power of chlorine is reduced as the pH value of the water increases.

(5) Free chlorine residual. At the same concentration, the free chlorine residual is a more effective disinfectant than the combined chlorine residual.

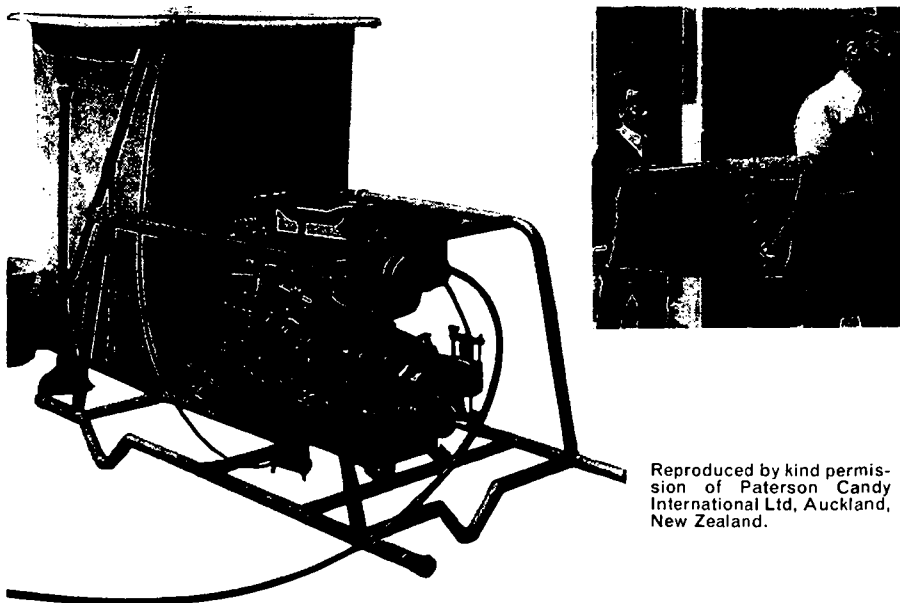
Methods of chlorination are:

(1) *Gas chlorinators*. These machines draw chlorine gas from a cylinder containing liquid chlorine, mix it in water and inject it into the supply pipe. Mobile gas chlorinators are made for field use.

(2) *Hypochlorinators*. These are less heavy than gas chlorinators and more adaptable to emergency disinfection. Generally, they use a solution of calcium hypochlorite or chlorinated lime in water and discharge it into a water pipe or reservoir. They can be driven by electric motors or petrol engines and their output can be adjusted (see Fig. 11).

Hypochlorinators are small and easy to install. They consist usually of a diaphragm pump and standard accessories, including one or more rubber-lined solution tanks, and a chlorine residual testing set. The usual strength of the solution is 0.1%, and it seldom rises above 0.5%.

FIG. 11. A PORTABLE CHLORINATOR



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Improvisation is an unavoidable necessity during post-disaster operations. The following description is of an improvised device used in Yugoslavia.<sup>1</sup>

In essence the chlorinator consists of a balance fixed to a wooden frame. From the long arm of the balance hangs a vessel for the chlorine solution, and on the short arm a regulator controls the inflow of the solution by pressing against the rubber feed tube; a bag of sand hangs from the short arm to counterbalance the vessel on the long arm. The balance is fitted with two rubber tubes, one that feeds the chlorine solution into the vessel and another that siphons it from the vessel to the delivery point. The outflow is controlled by adjusting the height of the delivery tube, which is fixed to a sliding support outside the frame. It can be set by hand to the required dose of chlorine (Fig. 12).

The wooden frame is 55–60 cm long and 35 cm high. To ensure stability the baseboard is 20 cm wide. The rest of the frame can be made of boards 10 cm wide. The short arm for the inflow regulator and the counter-weight is 15 cm long, while the long arm that holds the vessel is 25 cm long. A sharp-edged piece of wood acts as inflow regulator when pressing against the rubber tube.

The chlorine solution is kept in various types of container, usually in barrels. To complete the improvised device, a float (e.g., a spent electric light bulb or a piece of wood) is fixed to the immersed end of the rubber tube to ensure that the solution of chlorine drawn off is clear and does not contain bleaching powder sediment.

The chlorinator operates by balancing the outflow and inflow of the solution. The apparatus is so adjusted that the outflow regulator only lets pass a certain number of drops. When the number of drops delivered to the water supply is equal to the number

<sup>1</sup> Gjorgov, A. (1964) *Zdrav. nov. (Zagreb)*, 17, 72.



fed into the vessel, equilibrium is established. Once the vessel is full any additional supply of solution increases its weight and breaks the equilibrium; the regulator presses against the feeding tube, and the supply is interrupted until the balance is restored. The chlorinator is started by lowering the support of the delivery tube until the flow is established, when it is adjusted to the proper height that delivers the required amount of solution. The apparatus stops when there is any blockage.

The use of this type of chlorinator has proved to have the following advantages:

(1) Cheapness and speed of construction (2-3 hours of work for a semi-skilled worker, 4 short boards, a piece of plywood, 1 ½-2 m of rubber tube, a corrosion-proof vessel, and a few nails).

(2) The apparatus is easy and simple to handle and install anywhere.

(3) The use of the most easily obtainable disinfectant—bleaching powder—reduces running costs.

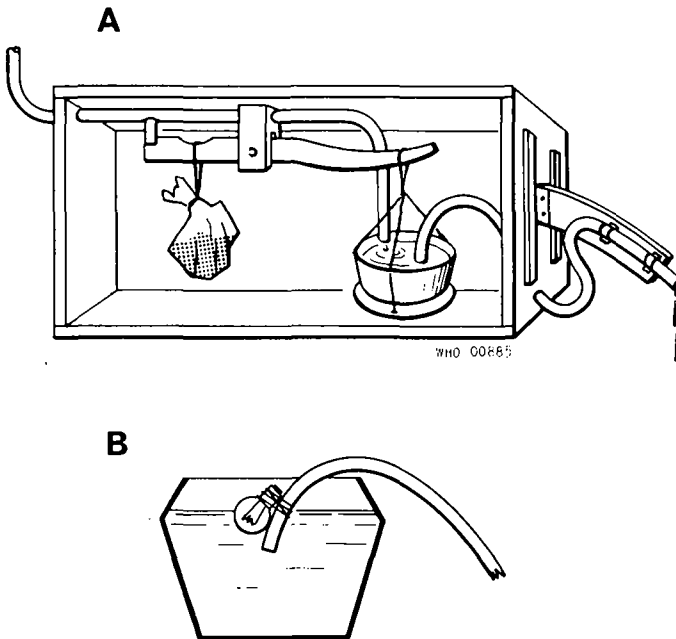
(4) The apparatus is suitable for use in small gravity water supplies, yielding 3-10 litres per second (in circumstances where expensive chlorinators are not suitable).

(5) The apparatus is not big and does not take up much space.

(6) The apparatus is corrosion-proof.

(7) No blockages occur.

FIG. 12. AN IMPROVED CHLORINATOR



Reproduced from Gjorgov, A. (1964) *Zdrav. nov. (Zagreb)*, 17, 74.

(3) *The batch method.* In the absence of chlorinators, water is disinfected by the batch method. This method is more likely to be used in emergencies. It involves applying a predetermined volume of chlorine solution

of known strength to a fixed volume of water by means of some gravity arrangement. The strength of the batch solution should not be more than 0.65 % of chlorine by weight, as this is about the limit of solubility of chlorine at ordinary temperatures. For example, 10 g of ordinary bleaching powder (25 % strength) dissolved in 5 litres of water gives a stock solution of 500 mg/litre. For disinfection of drinking water, one volume of the stock solution added to 100 volumes of water gives a concentration of 5 mg/litre. If after 30 minutes' contact the chlorine residual is more than 0.5 mg/litre, this dosage could be reduced.

After the necessary contact period has elapsed, excess chlorine can be removed to improve the taste by such chemicals as sulfur dioxide, activated carbon, or sodium thiosulfate. The first two are suitable for permanent installations, whereas sodium thiosulfate is more suitable for use in emergency chlorination. One tablet containing 0.5 g of anhydrous sodium thiosulfate will remove 1 mg/litre of chlorine from 500 litres of water.

Fig. 13 and 14 show two types of device that can be used for applying stock solutions. The first is a simple but reliable device for discharging a batch-mixed chlorine solution into a tank, open conduit, well, etc. When the device is used in conjunction with a water-seal tank and float valve, the solution can be discharged into the suction side of a pump. When the liquid level in the water-seal tank is above the hydraulic gradient, stock solution can be fed into a closed conduit. The wooden float maintains a constant head at the orifice, which can be made large enough to prevent clogging. If the device shown in Fig. 14 is carefully constructed with tanks and barrels lined with asphalt or some other corrosion-resistant material, this can be a semi-permanent method of applying stock chlorine solution.

Another simple apparatus for applying chlorine solution to water has been developed in Sudan.<sup>1</sup> It consists of an inverted plastic jerrican with a hole cut in the base (Fig. 15).

The float is made of light packing material. A glass tee is used for drawing the solution out of the jerrican, and the stem of the tee is tapered off when hot to reduce the diameter of the open end. Several tees of different openings are made and tested to determine the discharge flow. The strength of the solution is adjusted so as to deliver the required amount of chlorine.

The materials required for this device are as follows:

*Chlorinator :*

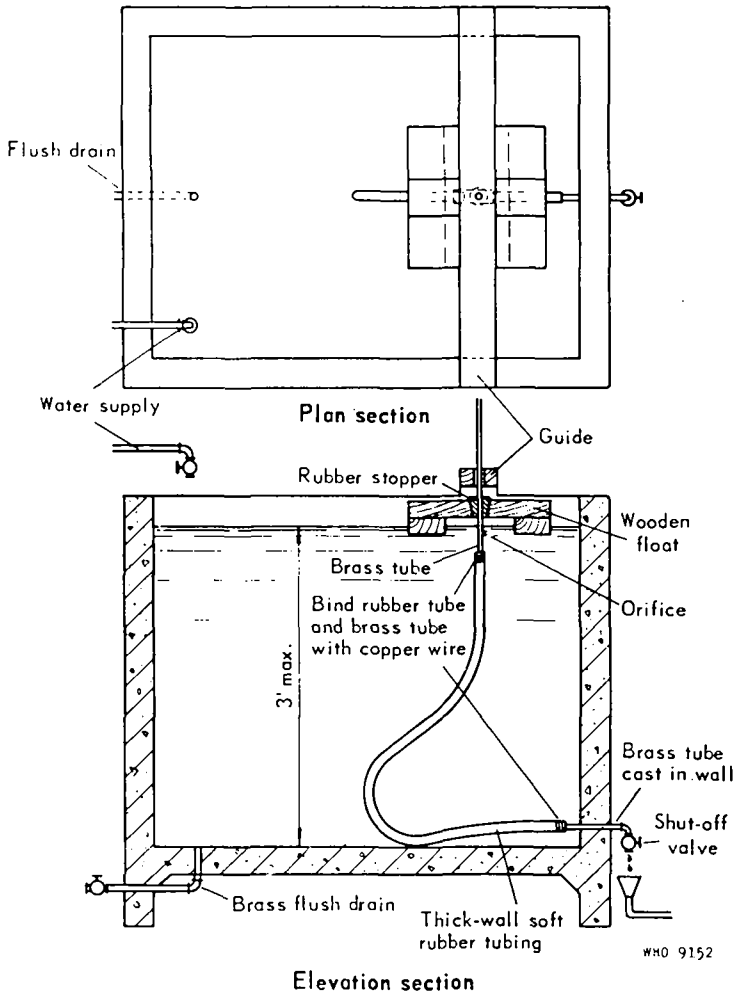
- 1 plastic 25-litre jerrican
- 1 float of plastic foam (28 × 12 × 1.2 cm)
- 3 glass tees, external diameter 7 mm, stems tapered to give various intake openings
- 3 rubber stoppers, 25-29 mm diameter
- 1 rubber tube, external diameter 9 mm, internal diameter 6 mm, length 120 cm, extremely flexible

<sup>1</sup> Grombach, H. E. (1966) *Study on rural water treatment plants in the Sudan Gezira*, Geneva (unpublished WHO report).

*Auxiliary materials :*

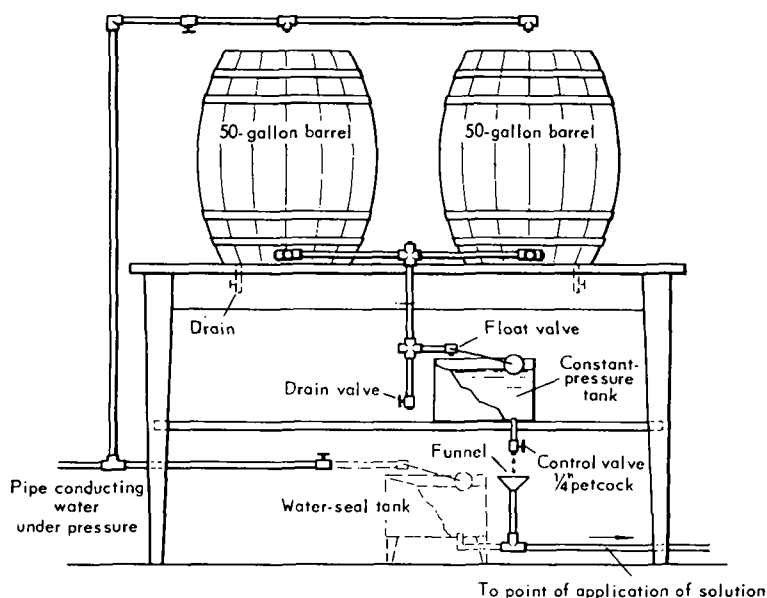
- 1 plastic funnel
- 1 measuring cup
- 1 plastic tube, external diameter 12 mm, internal diameter 9 mm, length as required (about 10 m)
- 2 plastic 5-litre buckets for preparing chlorine solution

FIG. 13. EQUIPMENT FOR FEEDING HYPOCHLORITE SOLUTION



Reproduced from Bulletin No. 21, New York State Department of Health, USA.  
 Note: Brass material may be replaced by plastic.

FIG. 14. APPARATUS FOR HYPOCHLORINATION



WHO 9253

The water-seal tank and connecting piping are not needed when the solution is discharged into an open conduit, pump well, etc., but must be used when the solution is discharged into the suction side of the pump.

(4) *Continuous chlorination.* This method, in which porous containers of calcium hypochlorite or bleaching powder are immersed in water, is used mainly for wells and springs but is also applicable to other types of water supply. It has been developed in Bulgaria and some other countries with good practical results. A description of its application in Bulgaria<sup>1</sup> is summarized below:

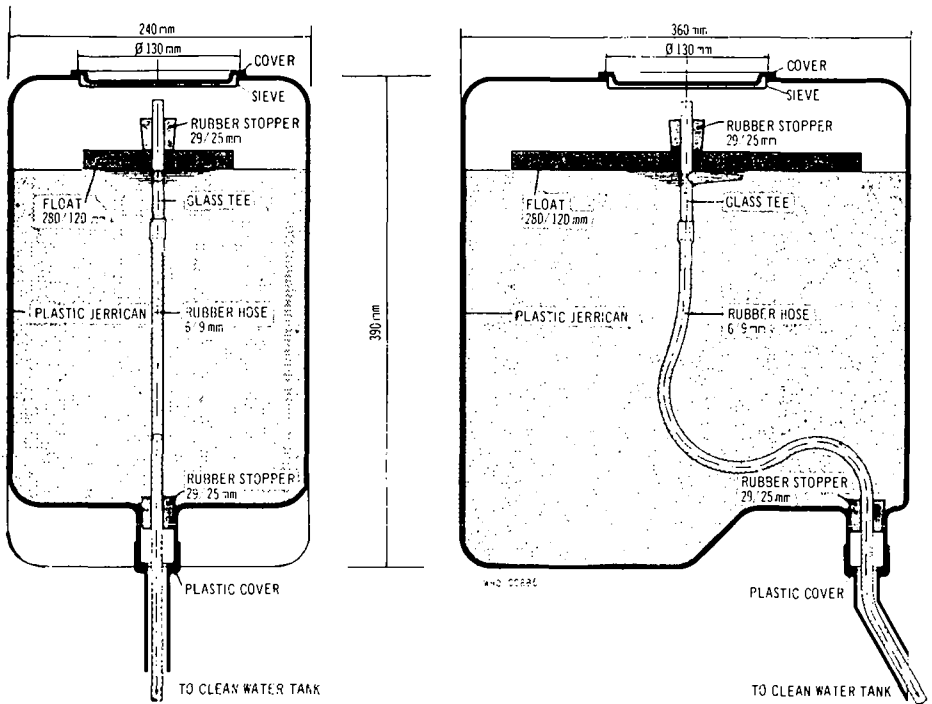
The device for controlling the dosage of active chlorine is a cylindrical, hollow earthenware vessel known as a "dosing cartridge" (Fig. 16). This cartridge is made of infusorial earth or ordinary potter's clay, which ensures sufficient permeability for active chlorine to percolate through it.

The cartridge is packed with moistened bleaching powder or hypochlorite, and tightly closed with a rubber stopper. It is immersed in water until the active chlorine begins to percolate; this takes from 12 to 24 hours.

The quantity of active chlorine that passes through the cartridge depends on the strength of the compound, the porosity of the walls, and the surface area of the cartridge in contact with the water.

<sup>1</sup> Zdravkev, M. (1959) *New method of chlorinating drinking water*, Geneva (unpublished WHO report).

FIG. 15. PLASTIC JERRICAN CHLORINATOR



The size and number of cartridges used should be selected according to requirements; their adequacy can be checked by determining the amount of chlorine residue. As percolation depends on the surface area of the cartridge immersed in the water, it is possible to regulate the amount of chlorine delivered by raising or lowering the cartridge (Fig. 17).

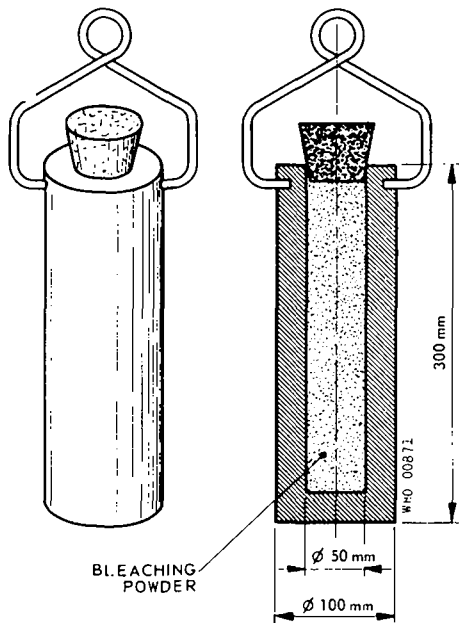
Most frequently, emergency chlorination is carried out in reservoirs. One or more cartridges must be placed so as to ensure the free discharge and even distribution of the chlorine throughout the water entering the reservoir. This may be achieved in 2 ways:

(1) A small quantity of water is diverted from the inlet pipe to a small vessel in which the cartridges stand upright. As the quantity of water diverted is proportional to the amount flowing through the inlet pipe, the water level in the vessel rises or falls according to the amount of water entering the reservoir, and by covering the cartridges to a greater or lesser extent automatically regulates the percolation of chlorine.

(2) Cartridges may be immersed at the discharge channel or flume of the reservoir through which the whole quantity of water passes. This method is also applicable to storage tanks and water towers of small water systems with a flow of up to 5 litres per second.

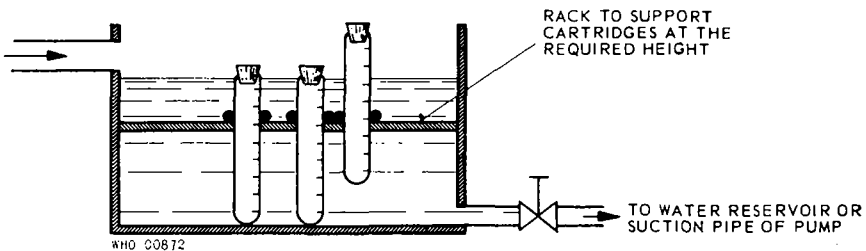
In the case of pumped water, the delivery pipe from the vessel containing the cartridges is connected to the suction pipe of the pump. The operator must immerse or remove the cartridges when he starts or stops the pump. In automatically operated pumps, the lowering and raising of the cartridges can also be made automatic by using the change in water pressure in the discharge pipe of the pump to move a lever arm from which the cartridges are suspended.

FIG. 16. STANDARD DOSING CARTRIDGE FOR CHLORINATION OF DRINKING-WATER



This cartridge has a capacity of 480 g of bleaching powder and an active chlorine release rate of about 40 mg per hour.

FIG. 17. VESSEL WITH DOSING CARTRIDGES FOR CONTINUOUS CHLORINATION



Continuous disinfection of protected wells and springs is especially important in areas where ground water is less than 3 m below the surface. Dosing cartridges should be immersed in a suitable place to ensure complete disinfection of all the water drawn from a well or spring.

In the case of open wells, cartridges may be lowered into the water. The number and size of cartridges selected, which determine the amount of chlorine released, should be varied according to the volume of water in the well and the rate at which it is drawn off. To ensure even chlorination of water obtained from springs, the cartridges may be

placed in a water chamber at the point of abstraction, in such a way that they are completely covered with water at the maximum rate of flow. If the flow decreases, the level in the water chamber falls and the area of the cartridge immersed is reduced; as a result the amount of active chlorine released decreases proportionally.

In using dosing cartridges the following precautions must be taken:

- (1) Before charging, the condition of the cartridge must be checked to ensure that it is not cracked and that the rubber cork fits firmly, etc.
- (2) The cartridge must be charged with a compound of known active chlorine content.
- (3) The water in a well should not be used for 24 hours after immersion of a newly charged cartridge.
- (4) Chlorine residual tests should be carried out regularly and supplemented by bacteriological examination, if possible.
- (5) Cartridges should be replaced before they are empty.
- (6) Spare cartridges should be kept at hand.

A free residual chlorine level of 0.7 mg/litre should be maintained in water treated for emergency distribution. A slight taste and odour of chlorine after half an hour gives an indication that chlorination is adequate. In flooded areas where the water distribution system is still operating, higher chlorine residuals should be maintained. Occasionally, an unpleasant taste develops from the reaction of chlorine with phenolic or other organic compounds. This taste should be accepted, as it is an indication of safe disinfection.

## 2. Coagulation—disinfection

Part of the suspended matter in turbid water will settle if left undisturbed for several hours. The addition of chemicals such as alum, ferric chloride, and ferrous sulfate hastens the settling process since these compounds help to form a "floc" of larger particles by reacting with and adhering to the suspended matter. This process is known as coagulation and the chemicals used are called coagulants. The floc becomes heavier and settles readily. Removal of the organic matter greatly lessens the amount of chlorine needed for disinfection.

There are many factors that govern the coagulation process. These include:

(1) Hydrogen-ion concentration. The optimum pH value for coagulation is the value that provides the best floc formation and settling. The pH value of the water changes when coagulants are used and has to be adjusted to its optimum value by the addition of alkalis or acids.

(2) Mixing. Coagulants must be thoroughly mixed with the water to give satisfactory results. This may be accomplished by (a) pump action, whereby the coagulant solution is added to the suction pipe of the pump and the pump does the mixing; (b) the drip-bottle method, i.e., hanging a drip-bottle over the discharge pipe or hose of raw water that feeds the

tank and letting the coagulant solution drip on to the water jet; or (c) dissolution, i.e., allowing the discharge of raw water to splash on to a basket containing solid coagulant.

(3) Coagulant dosage. The amount of coagulant and chemicals required to adjust the pH value of the water may be calculated when the pH and the type of alkalinity are known. However, optimum dosage for a given water may be determined approximately using the jar test. Information on chemicals used for coagulation and for adjusting the alkalinity of water is presented in Table 2.

### 3. Coagulation—filtration—disinfection

In this method filtration is added to the procedures described above. If temporary reservoirs can be arranged, it is preferable to let the water settle before filtering it. In mobile purification units, however, the water is filtered through a pressure filter without settling. They usually have a capacity of 4000–7000 litres per hour, and consist essentially of: (a) a centrifugal pump directly coupled to a gasoline engine; (b) a filter (pressure, rapid sand filter); (c) a hypochlorinator; (d) chemical solution tanks (one for alum and one for soda ash); (e) a chlorine solution tank; (f) hose adapters; (g) valves (pump suction, inlet, drain, air release, outlet, flow control, etc.); and (h) a tool box. Instructions in the manuals supplied with such units must be followed.

### 4. Filtration—disinfection

In this method water is mixed with diatomaceous earth, then passed through the filter unit in which filtering partitions (septa) are installed (Fig. 18, 19). Mobile purification units using this process have been produced with capacities up to 50 000 litres per hour. They consist essentially of: (a) a centrifugal pump driven by a rope-started gasoline engine; (b) a filter (diatomite); (c) a hypochlorinator; (d) a slurry feeder and an air compressor; (e) a precoat and recirculating tank; (f) a chlorine solution tank; (g) hose adaptors; (h) valves (pump suction, inlet, drain, outlet, flow control, air release, etc.); and (i) a tool box. Instructions in the manuals supplied with such units must be followed.

### Storage

Emergency storage of water can be improvised in canvas, rubber-coated nylon and plastic containers, with a capacity up to 10 m<sup>3</sup>. Polyethylene containers erected in pits dug to size can provide up to 50 m<sup>3</sup> storage capacity. If the purpose of storage is only to provide contact time after chlorination, the minimum capacity should be such as to secure contact of at least 30 minutes. The total storage capacity for water distribution should be equal to the amount required for 12–24 hours. Elevated tanks can be set up within a short time by using drums, iron sheeting, or asbestos-



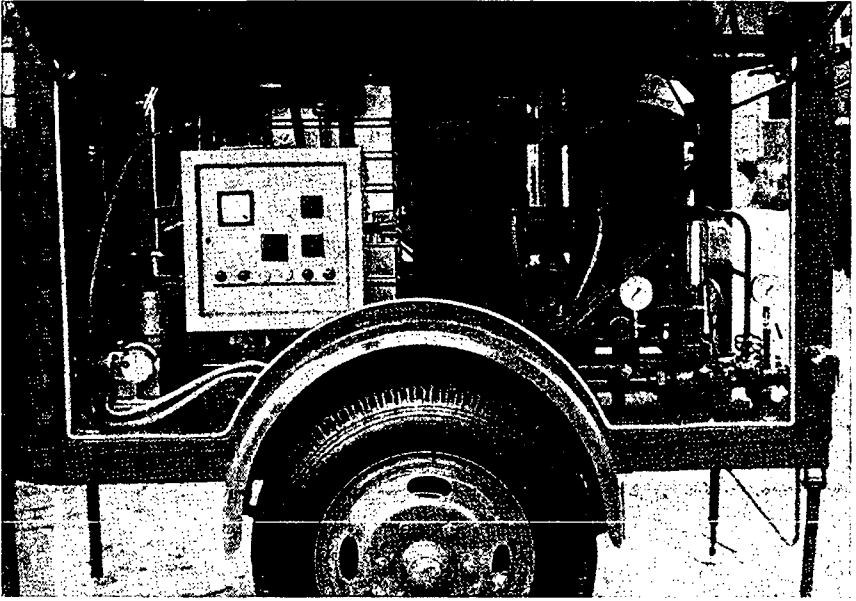
TABLE 2. CHEMICALS USED TO COAGULATE WATER OR ADJUST ITS ALKALINITY \*

Chemical (common names in parentheses)	Appear- ance	Use	Emer- gency sources	Dose grains/gal (mg/l)	Effective pH range	Natural alkalinity required in grains/gal or mg/l to react with one grain/gal or mg/l of coagulant	Artificial alkalinity required in grains/gal or mg/l to react with one grain/gal or mg/l of coagulant			Remarks
							Hydra- ted lime	Quick lime	Soda ash	
Aluminium sulfate  (alum, filter alum, sulfate of alumina)	Light tan to grey-green crystals	Coagulant	Hardware store, fertilizer store or chemist's shop (pharmacy)	0.3-3.0 (5.1-51.0)	4.4-6.0 5.7-8.0 9.0-10.5	0.45	0.35	0.28	0.48	4.4 to 6.0 pH range used for highly coloured water. 5.7 to 8.0 pH range used for turbid and moderately col- oured water. 9.0 to 10.5 pH range used in alum coagulation of carbo- nates in lime-soda softening.
Aluminium ammonium sulfate  (ammonia alum)	White crystals	Coagulant	Large swimming pools	0.3-6.0 (5.1-103.0)	5.7-8.0	0.29 approx.	0.23 approx.	0.18 approx.	0.31 approx.	Less soluble than filter alum. Use is generally restricted to swimming pools and pres- sure filters. Ammonium con- tent is available.

Ferrous sulfate  (copperas, iron sulfate, sugar sulfate, green vitriol)	Green to brownish-yellow crystals	Coagulant	Fertilizer store	0.3-3.0 (5.1-51.0)	8.5-11.0	—	0.27	0.22	Not normally used	
Sodium carbonate  (soda ash)	White lumps, crystals, or powder	To adjust pH or remove permanent hardness	Hardware store or chemist's shop (pharmacy)	0.1-2.0 (1.7-34.0) for pH adjustment	—	—	—	—	—	Readily soluble.
Calcium hydroxide  (slaked lime)	White lumps or powder	To adjust pH or remove carbonate hardness	Fertilizer store	0.1-3.5 (1.7-60.0) for pH adjustment	—	—	—	—	—	Only slightly soluble, so fed as a suspension.
Calcium carbonate  (limestone, chalk)	White lumps	To adjust pH	Fertilizer store	0.1-3.5 (1.7-60.0)	—	—	—	—	—	Must be crushed to powder before use.
Sodium hydroxide  (caustic soda, lye)	White flakes	To adjust pH	Grocery store, hardware store	0.1-2.0 (1.7-34.0)	—	—	—	—	—	Readily soluble and very corrosive.

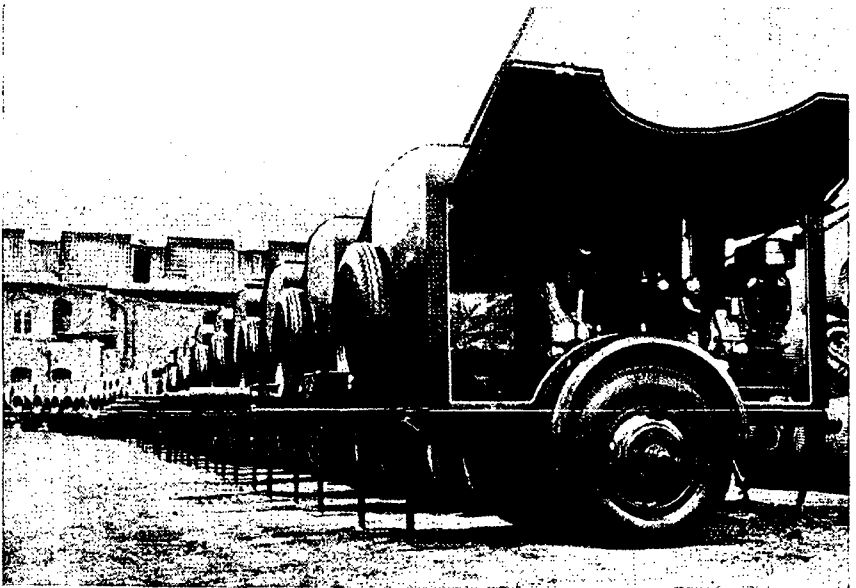
\* Adapted from: US Department of Health, Education and Welfare (1961) *Health mobilization course manual*, Washington, D.C.

FIG. 18. MOBILE DRINKING-WATER UNIT, MOUNTED ON SINGLE-AXLE TRAILER



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FIG. 19. MOBILE DRINKING-WATER UNITS, CAPACITY 10 000 LITRES PER HOUR



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cement tanks. Wooden poles, timber, or iron tubing can be used for the supports. In many countries elevated storage tanks are manufactured in standard sizes with all parts prefabricated. They can be transported and erected rapidly.

In long-term emergency camps all reservoirs should be covered, primarily for protection from sunlight and consequent growth of algae that produces tastes in the water, and secondarily for protection from birds, insects, and dust. The roof may be made of asbestos-cement sheets or corrugated iron sheets. An overflow pipe should be provided, care being taken that the overflow water will not endanger the foundations. The inlet pipe will normally discharge at the top of the reservoir and be fitted with a float valve. The outlet pipe should be about 5 cm above the bottom of the tank. A small drain pipe should be installed flush with the bottom of the tank, and a manhole on the roof is necessary to permit cleaning, inspection and repair. The openings of vent pipes should be screened to keep out insects and small birds.

### *Tests*

Until the laboratory facilities of urban water supply systems can be restored to normal operation, complete tests of water samples should be made at laboratories in the vicinity of the disaster area. The most important tests to be carried out under emergency and field conditions are:

- (1) determination of residual chlorine (free and combined);
- (2) bacteriological examination for coliform bacteria;
- (3) determination of hydrogen-ion concentration;
- (4) determination of type of alkalinity.

Techniques, media, and equipment have been developed for the application of membrane filters in the bacteriological examination of water under field conditions. Residual chlorine, hydrogen-ion concentration, and type of alkalinity can be determined by the use of appropriate colour indicators. The procedures for these tests are described briefly hereunder:

#### *1. Test for residual chlorine*

Free chlorine in acid solutions produces a strongly yellow compound when it reacts with orthotolidine. Pocket colour comparators based on this reaction are made for field use. The pH value of water interferes with this test, and highly alkaline water samples should be first neutralized by an acid. To eliminate the effect of interfering substances (such as chloramines), the orthotolidine arsenite method described in the *International standards for drinking-water* should be used:

Label three comparator cells, or French square bottles, A, B, and OT. Use 0.5 ml of orthotolidine reagent in 10-ml cells, 0.75 ml in 15-ml cells, and the same ratio for other volumes of sample. Use the same volume of arsenite reagent as of orthotolidine.

To *cell A*, containing orthotolidine reagent, add a measured volume of the water sample. Mix quickly, and immediately, within 5 seconds, add arsenite reagent. Mix quickly again and compare with colour standards as rapidly as possible; record the result. The value obtained (A) represents free available chlorine and interfering colours.

To *cell B*, containing arsenite reagent, add a measured volume of the water sample. Mix quickly, and immediately add orthotolidine reagent. Mix quickly again and compare with colour standards as rapidly as possible; record the result as the  $B_1$  value. After exactly 5 minutes, compare again with colour standards and record the result as the  $B_2$  value. The values obtained represent the interfering colours present in the immediate reading ( $B_1$ ) and in the 5-minute reading ( $B_2$ ).

To *cell OT*, containing orthotolidine reagent, add a measured volume of the water sample. Mix quickly and, after exactly 5 minutes, compare with colour standards; record the result. The value obtained (OT) represents the total amount of residual chlorine present and the total amount of interfering colours.

#### CALCULATION

Total residual chlorine =  $OT - B_2$

Free available chlorine =  $A - B_1$

Combined available chlorine = total residual chlorine — free available chlorine.<sup>1</sup>

### 2. Test for coliform bacteria (membrane filters)

The procedure consists of passing a water sample through the filter, putting the filter membrane on an absorbent pad saturated with a differential (Endo-type) culture medium for incubation, and examining it for the development of coliform colonies, which have a characteristic appearance.

The manufacturers of membrane filters have produced test kits for field use. Workers should follow the detailed procedures described in the instruction manuals supplied with the kits or in the *International standards for drinking-water*.<sup>1</sup>

### 3. Determination of hydrogen-ion concentration

Certain organic compounds change colour at different pH values, and can be used as indicators. When a small amount of these compounds is added to a sample of water, a colour develops: the pH value of the water can be determined by comparing the colour with a scale of standard colours mounted on a disc. Indicators used for this purpose are as follows:

<i>Indicator</i>	<i>pH range</i>	<i>Colour change</i>
Methyl red	4.4–6.0	Red to yellow
Bromothymol blue	6.0–7.6	Yellow to blue
Phenol red	6.8–8.4	Yellow to red
Thymol blue	8.0–9.6	Yellow to blue

For field tests a few drops of bromothymol blue are added to 10 ml of water, and the colour that develops is compared with the colour standards.

<sup>1</sup> *International standards for drinking-water*, 2nd ed., Geneva, World Health Organization, 1963.

If the standards are not available, the result can be interpreted in the following manner:

<i>Colour</i>	<i>Approximate pH</i>
Dark blue	7.6
Light blue	7.0
Green	6.8
Greenish yellow	6.4
Yellow	6.0

Paper tapes soaked in indicators can also be used in the field.

#### *4. Determination of type of alkalinity*

There are 3 kinds of alkalinity: hydroxide (OH), normal carbonate (CO<sub>3</sub>), and bicarbonate (HCO<sub>3</sub>). These types can be differentiated by acid titration and the use of different indicators, but are seldom determined in the field under post-disaster conditions.

#### *Distribution*

In most emergencies water is distributed from tankers (Fig. 20), which may be provided by fire brigades, the army, dairies, beverage plants, or other sources. Each family may be issued with a water container made of plastic or galvanized iron. A tanker with a storage tank (or tanks) at the site should be able to provide water for 1000 persons. Environmental health workers are responsible for seeing that the tankers are filled from acceptable sources in a hygienic manner and chlorinated under their supervision.

If there is a municipal distribution system within reasonable distance, it may be possible to extend this to a temporary camp by means of light and quick-coupling steel or plastic pipes. In long-term camps, distribution pipes may be laid to feed water points. Water points usually have 2 or more taps and one tap should be provided for every 100 persons. No shelter should be more than 100 m from a water point.

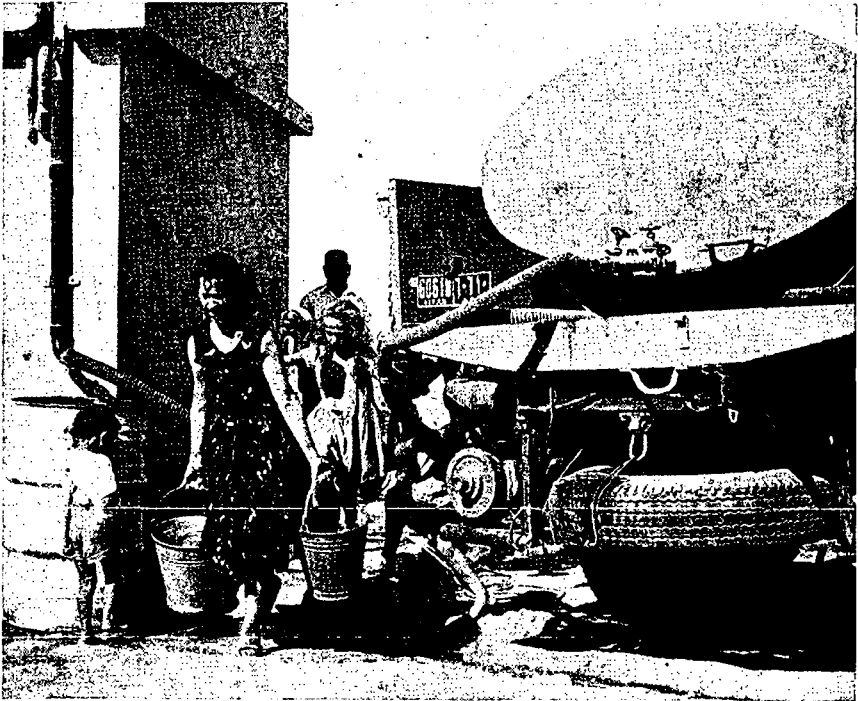
#### *Physical protection*

In emergency situations, the physical protection of water supplies for the use of refugees is a major consideration. In addition to such barriers as walls and fences, guards may be necessary to prevent mobs from over-running and damaging treatment units, pumping stations, tankers, distribution stations, and temporary collection facilities. Intake structures, wells, and springs should also be protected against misuse. The character and extent of such protection will depend on the local situation.

#### *Ice supply*

In hot climates, the relief authorities may distribute ice to refugees. Ice should be supplied from a commercial manufacturing plant where it is made from safe water and where sanitary regulations are observed.

FIG. 20. DISTRIBUTION OF WATER FROM A TANKER



It should be distributed in trucks designed for the purpose, equipped with tools for the safe handling of ice. Each family should have a covered container (insulated, if possible) for storing ice.

## Waste disposal

### *Excreta disposal*

Unsatisfactory disposal of excreta is common immediately after natural disasters. Unless prompt measures are taken to provide proper means of disposal, the following environmental problems may be created:

- (1) creation of fly breeding-places;
- (2) development of unpleasant odours;
- (3) contamination of soil and of sources of water;
- (4) contamination of food by flies and dust;
- (5) increase in the incidence of disease, especially enteric and helminthic diseases.

The measures applicable depend on the nature of the existing facilities.

### *1. Cities and towns with sewerage systems*

When a disaster occurs, sewerage and sewage treatment installations in cities and towns may be put out of service. For example, earthquakes may cause breaks in main sewers and collectors or destroy the sewage treatment plants and pumping stations; floods may block the sewers and inundate pumping stations and treatment plants. Emergency situations may also be caused by the discharge of industrial wastes containing inhibitory toxic substances into the sewerage system, so disturbing the biological processes involved in the treatment of sewage.

Measures that can be applied include:

- (1) rapid repair of sewers, with temporary arrangements to by-pass damaged sections;
- (2) cleaning and flushing blocked sewers;
- (3) dewatering pumping stations and the treatment plant;
- (4) by-passing the sewage treatment plant (especially in the case of flooding, where great dilution makes this permissible);
- (5) hauling sludge to a burial site or another sewage treatment plant in the neighbourhood;
- (6) treating sewers with strong disinfectants to prevent the spread of pathogenic organisms and to mask the smell of flood water and sewage from the smashed sewers;
- (7) providing temporary installations (see below).

Every effort should be made to put the sewerage system back into operation. The sanitary engineer may have to make a survey and prepare a damage report. This report should include:

- (1) an estimate of the number of breaks or obstructions in sewer lines, lengths and sizes of pipes that need to be replaced, and a list of necessary repair equipment such as pumps, bulldozers, excavating machinery, trucks, and tools, and of the construction materials, supplies, and labour required;
- (2) a statement of conditions at the disaster site, indicating the extent of flooding in basements and streets;
- (3) an estimate of the equipment, materials, and men needed to put the sewage treatment plant and pumping stations back in working order;
- (4) recommendations concerning points where sewage could be discharged temporarily;
- (5) an appraisal of the need for providing privies if the sewage service cannot be restored quickly.

Generally, any repairs made to sewer lines during the emergency should be of a permanent nature. However, temporary repairs may be necessary where a sewer line or manhole must be replaced quickly to restore traffic on a main street. Asbestos-cement pipes, wooden conduits or some other type of quick-coupling pipes should be used to expedite emergency repairs.



## 2. *Temporary shelters and camps*

Depending on the length of time that temporary shelters or camps are expected to be in use, excreta disposal installations of different types and varying service life must be provided. The most suitable types are: (a) shallow trench latrines; (b) deep-trench latrines; (c) pit privies; (d) bore-hole latrines; (e) aqua (or septic) privies; (f) urinals; and (g) mobile latrines.

The communal latrine, although unavoidable in many emergency situations, is difficult to keep clean; it should therefore be used only where the emergency is not expected to last long. Strict measures are needed for control and cleanliness. Attempts should be made to provide communal latrines with water so that cleaning is practicable. Five seats should be provided for every 100 persons, in separate blocks for men and women. Latrines should be located downhill from any water source and at least 15 m away from it. Where the ground-water is used for drinking or other purposes, the bottom of the latrine should be at least 1.5 m above the ground-water table; in the presence of limestone formations and fissured rocks, additional precautions are necessary to protect sources of water supply. The site should be dry, well drained, and above flood level; the immediate surroundings of latrines should be cleared of all vegetation, wastes and debris.

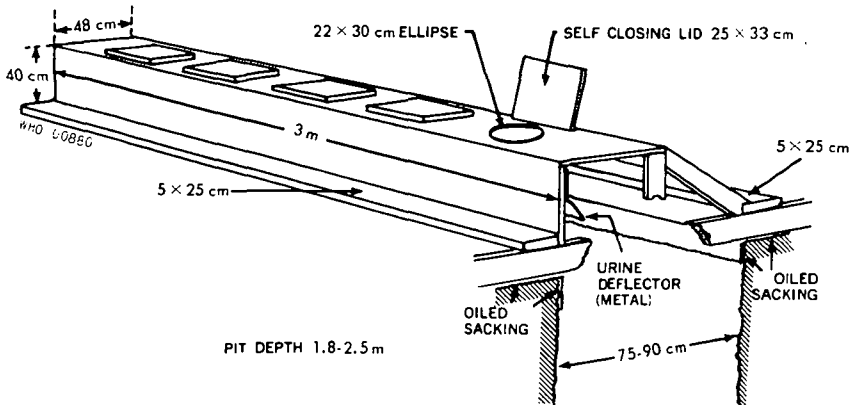
The various types of excreta disposal installation are described briefly below:

*Shallow trench latrine.* This is simply a trench dug with ordinary tools (picks and shovels). The trench is 30 cm wide and 90–150 cm deep. Its length depends on the number of users: 3–3.5 m are necessary for every 100 people. Separate trenches should be provided for men and women. The earth from the trench should be piled up at the side. Shovels should be left at the site, and people should be instructed to cover faeces with earth each time they use the latrine. However, these instructions may not be carried out and it will be necessary for the sanitation squad to complete the work twice a day to keep the fly population and odours under control. It may be necessary to place lumber or boards along the sides of the trench to provide for footing and to prevent the walls from caving in. Privacy may be secured by the use of brush, canvas, wood, or sheet-metal fencing. Toilet paper or ablution water (depending on local custom) should be provided.

The shallow trench is a rudimentary arrangement for a short period (up to one week). When the trench is filled to 30 cm below ground level, it must be covered with earth, heaped above ground level and compacted; if necessary, a new trench must be dug. Before a trench is abandoned, sanitation personnel should ascertain that it is properly filled in.

*Deep trench latrine* (Fig. 21). This type of latrine is intended for camps of longer duration, from a few weeks to a few months. The trench is

FIG. 21. DEEP TRENCH LATRINE



Adapted from: Canada, Department of National Health and Welfare (1967) *Environmental health in disaster*, Ottawa, p. 85.  
Trench revetted at sides. Anti-fly oiled sacking laid down for width of 1.25 m all round trench; wooden fly-proof cover of tongued and grooved wood on strong base.

1.8–2.5 m deep and 75–90 cm wide. The top of the trench is covered by a fly-proof floor. Depending on the local custom, a seat or a squatting hole is provided. A good superstructure is built for privacy and protection. Other requirements are the same as for shallow trenches.

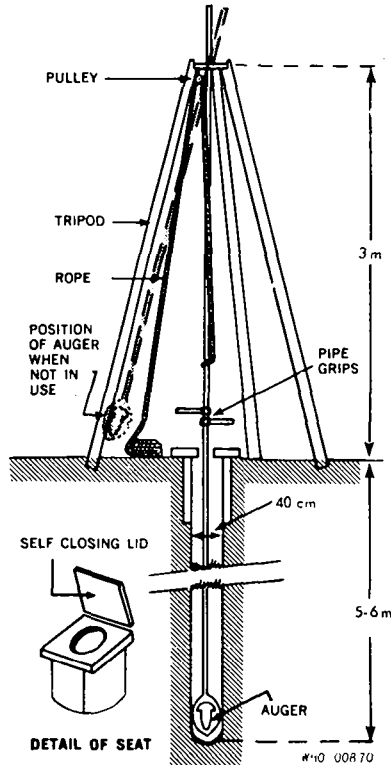
*Bore-hole latrine* (Fig. 22). In estuaries and places where the subsoil does not contain rock, this type of latrine offers a fast solution for excreta disposal in emergencies. With the use of earth-augers, family latrines could be set up for refugees. Mass production of concrete slabs for the latrine floor may be undertaken on the site. If the number of available augers is limited, shallow trenches may be used while bore-holes are being made.

*Pit privy*. Where the subsoil is loose and easy to dig up, a pit privy may be built for each family or for each tent sheltering a few families. If tools are provided, the refugees may do most of the work themselves. Mass production of flat concrete slabs for the latrine floors may be undertaken at the camp site. In long-term camps and where the local custom is to use water for cleansing, a water-seal could also be incorporated in each slab. A more permanent type of superstructure can be built. Details of the construction of pit privies are given in a WHO monograph on excreta disposal.<sup>1</sup>

*Aqua (or septic) privy*. This type of privy consists essentially of a water-tight tank (filled with water) in which excreta are discharged, stored and digested. It has been used with success in some long-term refugee camps as

<sup>1</sup> Wagner, E. G. & Lanoix, J. N. (1958) *Excreta disposal for rural areas and small communities*, Geneva (World Health Organization: Monograph Series, No. 39), p. 42.

FIG. 22. BORE-HOLE LATRINE



Adapted from: Canada, Department of National Health and Welfare (1967) *Environmental health in disaster*, Ottawa, p. 86.

The bore-hole latrine is a vertical boring usually 40 cm in diameter and anything up to 6 m deep. A fly-proof seat superstructure should be provided. The boring is made by a special hand-operated auger, the shaft of which is made in sections for easy transport and to allow lengths to be added as the work proceeds. Shear legs are erected over the site of the boring to act as a guide for the upper end of the shaft and to provide a support for the pulley block used in withdrawing the auger from the ground. The auger is rotated by hand turning applied to a detachable cross-T handle which can be adjusted in the shaft as the boring deepens. If the bore reaches water, this is of great assistance in the digestion of the sewage. When ground water is not reached, a concrete skin covering the base of the bore and extending for 60 cm up the sides will hold water poured in from the top for some time. This type of latrine should be provided with adequate hard standings and drainage around it and a centrally placed seat over the bore to ensure that the edges are not fouled. Such latrines will last for years and are a most satisfactory form of sewage disposal in the field.

a communal latrine. Aqua privies take rather a long time to construct and are not recommended during emergencies except, perhaps, for field hospitals, first-aid stations, and mass feeding centres. Details of the construction of aqua privies are given in the WHO monograph referred to above.<sup>1</sup>

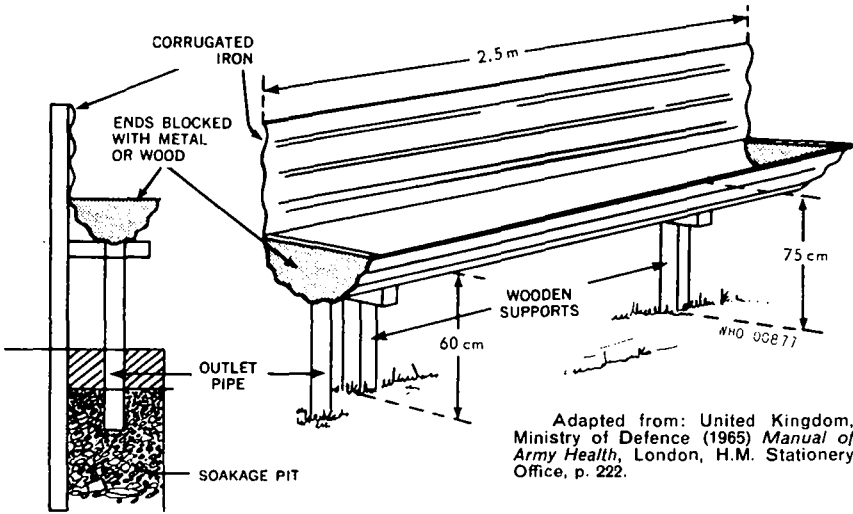
*Urinals.* These may be provided in communal blocks of latrines for men to reduce the number of seats needed. One urinal space for 25 males is

<sup>1</sup> Wagner, E. G. & Lanoix, J. N. (1958) *Excreta disposal for rural areas and small communities*, Geneva (World Health Organization: Monograph Series, No. 39), p. 76.

recommended. Odours from urinals can be kept under control by applying chlorine solution.

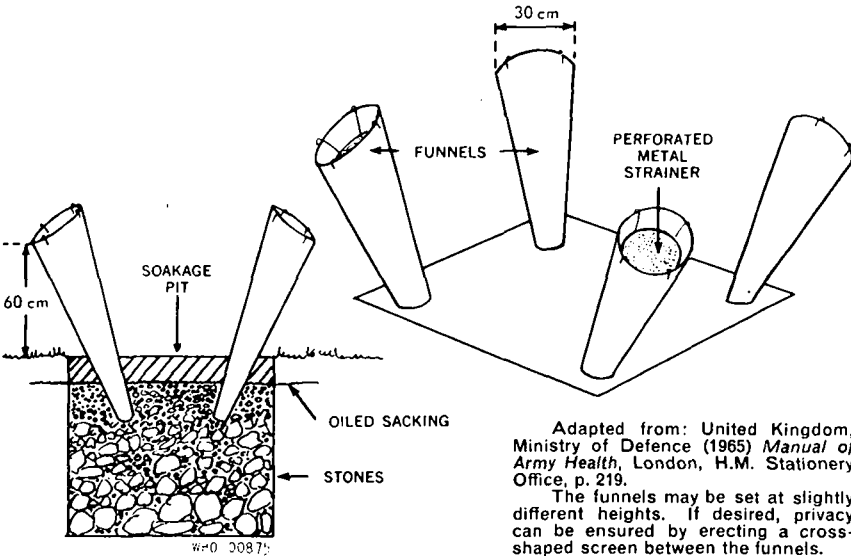
Two types of urinal are shown in Fig. 23 and 24, but many other designs are possible. Whatever the design chosen, a soakage pit should be provided (Fig. 25).

FIG. 23. TROUGH URINAL



Adapted from: United Kingdom, Ministry of Defence (1965) *Manual of Army Health*, London, H.M. Stationery Office, p. 222.

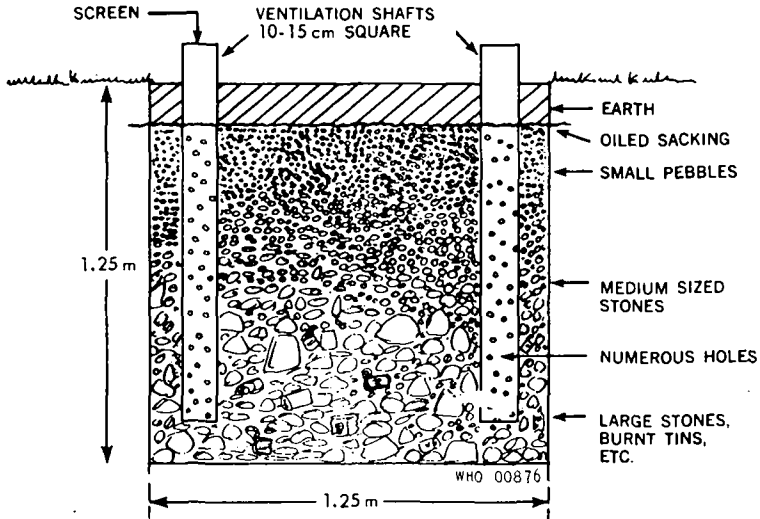
FIG. 24. FOUR-FUNNEL URINAL



Adapted from: United Kingdom, Ministry of Defence (1965) *Manual of Army Health*, London, H.M. Stationery Office, p. 219.

The funnels may be set at slightly different heights. If desired, privacy can be ensured by erecting a cross-shaped screen between the funnels.

FIG. 25. SOAKAGE PIT



Adapted from: Canada, Department of National Health and Welfare (1967) *Environmental health in disaster*, Ottawa, p. 88.

*Mobile latrines.* Mobile latrines are tanks mounted on a truck or a rail wagon; they are used in post-disaster situations and even in unsewered areas adjacent to urban centres in ordinary times. They are necessary in disaster areas where the ground-water table is high. Sanitation personnel are responsible for supervising the proper disposal of the tank contents and the washing and disinfection of tanks after each emptying.

#### *Solid wastes disposal*

Solid wastes to be disposed of may include (a) refuse; (b) manure; and (c) animal carcasses.

There is a correlation between the improper disposal of solid wastes and the incidence of vector-borne diseases. Provisions should therefore be made for the effective storage, collection, and disposal of refuse and manure. Carcasses should be disposed of as fast as possible. If the disaster area is urban and was provided with a proper collection and disposal service, or if the area is close to a municipal system, all efforts should be made to restore or extend the existing organization.

#### *1. Storage of refuse*

To expedite the disposal of refuse, it is advisable to provide separate containers for storing organic and inorganic wastes. The containers for organic wastes should be made of heavier material than those for inorganic wastes, and should be washable, watertight, and provided with tight-fitting,

overlapping covers. In emergencies, however, empty foodstuff containers and disposable water-resistant paper bags may be used for short periods. The capacity of containers should not exceed 100 litres. It is recommended that 3–4 containers be provided for every 100 persons. They should be so distributed that each family has a container within easy reach. The containers should stand off the ground, on wooden racks. In large emergency feeding centres, garbage stores may be practicable. They should have concrete floors and walls, floor drains, and a water supply; they should be emptied and washed every day.

### 2. *Collection of refuse*

An estimate should be made of the quantity of refuse, frequency of collection, number and size of collection vehicles, personnel required, method of final disposal, and disposal sites. In emergencies, all types of trucks may be used. However, the compacting type of refuse truck will reduce the number of trips and the hazards associated with the scattering of refuse. A truck with a capacity of 10 m<sup>3</sup> and manned by a driver and 2 helpers can serve 5000–8000 people, making 3 trips per day to the disposal area.

### 3. *Disposal of refuse*

Refuse may be disposed of by sanitary landfill, burial, incineration, and open dumping.

*Sanitary landfill.* For most situations sanitary landfill is the preferred method of final disposal. Heavy earth-moving equipment may be available from the army or the public works department. Refuse is compacted and promptly covered with earth, which is compacted in turn. Three methods are used in this operation:

(1) The trench method: a long trench is dug out and the excavated earth is used to cover the compacted refuse.

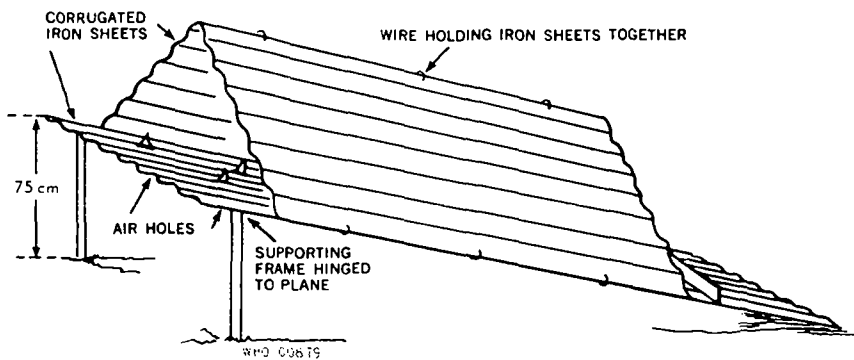
(2) The ramp method: the covering material is obtained from the working face of the fill.

(3) The area method: this method is used for filling land depressions and in swampy areas where soil conditions do not allow the use of heavy equipment.

*Burial.* This method is suitable for small camps where earth-moving equipment is not available. A trench 1.5 m wide and 2 m deep is excavated, and at the end of each day the refuse is covered with 20–30 cm of earth. When the level in the trench is 40 cm from ground level, the trench is filled with earth and compacted, and a new trench is dug out. The contents may be taken out after 4–6 months and used on the fields. If the trench is 1 metre in length for every 200 persons, it will be filled in about 1 week.

*Incineration.* Where burial is not practicable, refuse should be incinerated. If the refuse is very wet, fuel will need to be added. Refuse from first-aid stations and hospitals that contains pathogenic material should be incinerated, regardless of the method adopted for disposal of garbage and rubbish. A basket incinerator, which is simply a wire basket standing on an iron drum or stone supports, may be used for this purpose. Incinerators made of corrugated iron sheets are illustrated in Fig. 26 and 27. The incinerators shown in Fig. 28 and 29 are more suitable for long-term use. A little kerosene or fuel oil may be added to ensure complete combustion.

FIG. 26. INCLINED-PLANE INCINERATOR



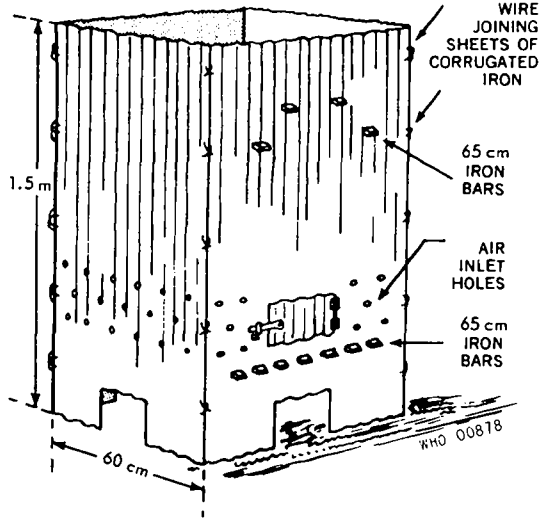
Adapted from: United Kingdom, Ministry of Defence (1965) *Manual of Army Health*, London, H.M. Stationery Office, p. 242.

A readily portable type of incinerator which folds flat when not in use. The V-shaped tongues cut in the base plate serve the dual purpose of supporting the refuse and providing draught apertures. For carrying purposes the wire along one of the edges is removed.

In the construction of incinerators used for the final disposal of any kind of refuse, it is essential to observe the following points:

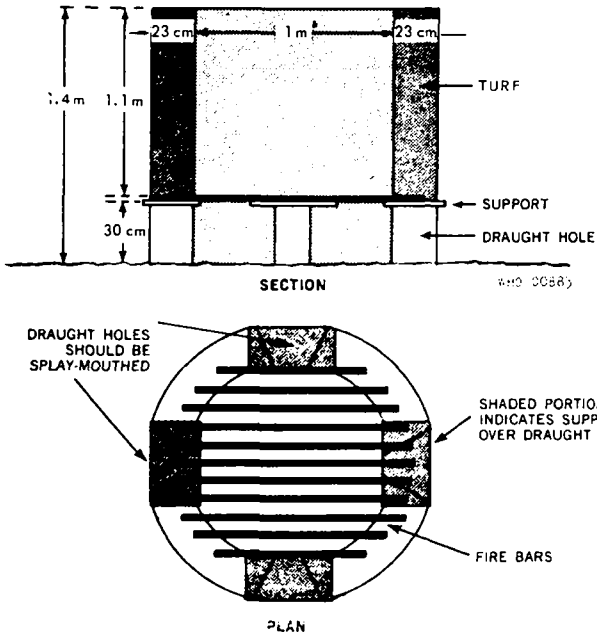
- (1) The incinerator should be located away and downwind from the camp or temporary shelters.
- (2) The incinerator should be built on an impervious base of concrete or hardened earth.
- (3) The air inlet must be sufficiently large; it should be funnel-shaped, narrow end inwards, to produce a blower effect.
- (4) The fire bars should be placed loosely on their support to allow for expansion.
- (5) The stoking gates should be suitably situated so that fresh material can be added from above.
- (6) The raking openings must allow sufficient room for efficient raking and for cleaning out the whole interior.
- (7) A long chimney is necessary for a closed incinerator, so as to ensure a good draught.

FIG. 27. OPEN CORRUGATED-IRON INCINERATOR



Adapted from: United Kingdom, Ministry of Defence (1965) *Manual of Army Health*, London, H.M. Stationery Office, p. 240.

FIG. 28. OPEN CIRCULAR TURF INCINERATOR

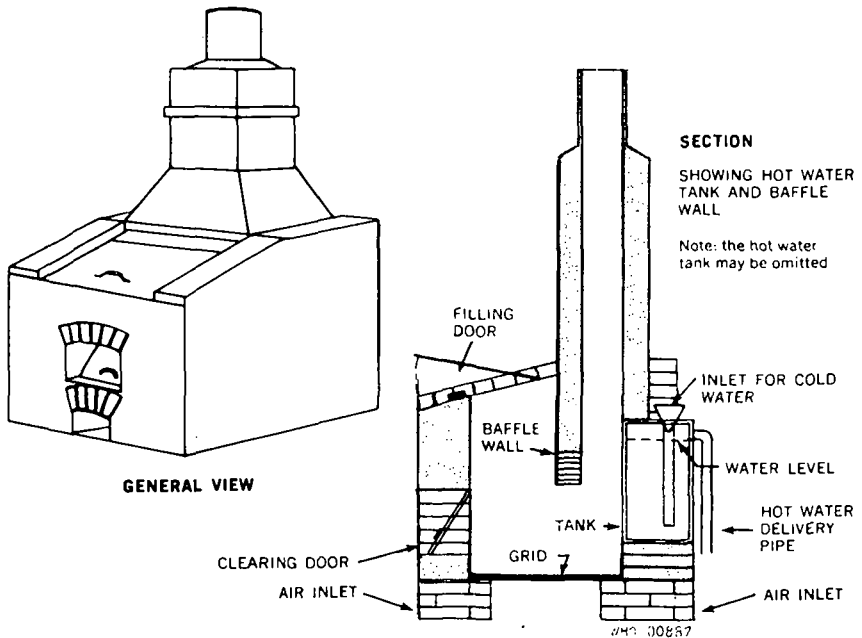


Adapted from: Canada, Department of National Health and Welfare (1967) *Environmental health in disaster*, Ottawa, p. 90.

The walls are built of bricks or stones laid loose or cemented together or of turfs measuring 30 x 23 cm. Turfs should be laid grass to grass and earth to earth. Iron fire bars 5 cm apart are built in 30 cm from the ground.



FIG. 29. BAILLEUL INCINERATOR



Adapted from: United Kingdom, Ministry of Defence (1965) *Manual of Army Health*, London, H.M. Stationery Office, p. 235.

This incinerator may be constructed of brick, stone, sheet metal or tins filled with earth, but the fire chamber should be lined with fire-bricks for prolonged use. Sheet metal is required for the raking and feeding doors. The consumption of fumes and smoke is ensured by an arched baffle wall. A supply of hot water for use at the incinerator site may be obtained by building a water tank into one of the walls.

*Open dumping:* This method must be avoided. In extreme emergencies only, refuse may be hauled to a suitable site for dumping and burning, provided that sanitation personnel supervise the operation. Cans should be crushed flat to prevent mosquito breeding, and burned refuse should be covered to deter flies and rodents.

#### 4. Manure

In rural disaster areas attention should be paid to the collection and disposal of manure because, if left in the open, it attracts flies and provides them with a good breeding-place. Pits with concrete floors and cement-lined walls may be built for manure collection. Each pit should be sufficiently large to hold 1 day's manure; 2 pits must be provided so that one can be cleaned and washed while the other is in use. The floor should slope towards a drain connected to a soakage pit (see Fig. 25). The owners of animals should be responsible for hauling the manure to these collection points. Daily removal for final disposal should be carried out by the camp's sanitation team.

Manure may be disposed of by burying, composting, and incineration, together with other refuse. In emergencies, the most practicable method is to bury it in trenches similar to those described for refuse. The contents of these trenches may be taken and used as soil conditioner after 4-6 months of anaerobic decay.

#### *5. Animal carcasses*

The problem of disposing of dead animals may assume serious proportions in certain natural disasters, floods in particular. Burial is slow and laborious: a pit 3 m deep is required for a dead horse. When there are many carcasses it is difficult to bury all of them, unless heavy excavation machinery is available. The burning of small animals, like cats and dogs, is feasible, but the burning of larger carcasses is difficult unless special incinerators are built. Efforts should therefore be made to obtain heavy equipment for burial. If this is not available, a combination of burial and burning should be used, i.e., burial of the internal organs and burning of the carcass with the aid of fuel. For better supervision, it is advisable to centralize operations in suitably located animal cemeteries. Carcasses awaiting burial should be sprinkled with kerosene or crude oil to protect them from predatory animals.

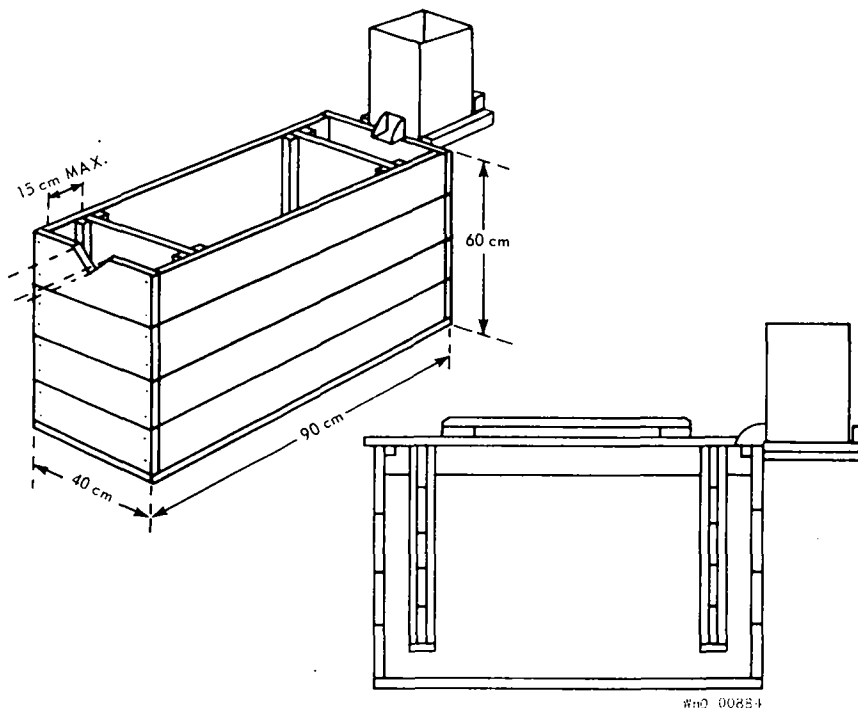
#### *Waste water disposal*

Waste water from field hospitals, mass feeding centres, milk distribution centres, and water points requires proper disposal. The usual way is to discharge it into a seepage pit. To prevent rapid clogging of this pit, a French drain or absorption trench may be constructed in advance of the pit. Liquid wastes from feeding centres and bath-houses contain grease and soap, and even where the soil is very porous seepage pits get clogged in time. It is therefore necessary to install a grease trap at the upper end of the inlet pipe to the drain and pit (Fig. 30). Dry water-courses may also be used if precautions are taken to prevent the breeding of mosquitos. Subsurface drainage can be recommended only for permanent camps. In areas where the soil is impermeable and the climate is hot and relatively dry, the waste water may be disposed of by evaporation. Shallow pans should be used for this purpose; they should be provided in pairs and used alternately to prevent mosquito-breeding.

#### **Food sanitation**

Food warehouses, wholesale and retail food shops, restaurants, etc. are frequently destroyed or damaged in a disaster, and much deterioration and spoilage of stored foodstuffs is to be expected. The interruption of electricity services may affect the operation of refrigerating plants, cold stores, and food processing plants, thus contributing to additional wastage of food.

FIG. 30. COLD-WATER GREASE TRAP



Adapted from: United Kingdom, Ministry of Defence (1965) *Manual of Army Health*, London, H.M. Stationery Office, p. 226.

Baffles should be removable, or ample space should be left beneath them for cleaning, and they should be spaced equally. Internal corners should be rounded.

An acute shortage of food may result from such damage, and outside help may be needed for feeding the afflicted population until the normal food supply is re-established.

Under emergency conditions the efficient control of food quality becomes difficult: laboratory services may not be available, and food inspection will have to be based on the appearance, physical condition, taste, and smell of food in relation to normal characteristics and keeping quality. Careful examination is required to determine whether food is unaffected and still fit for human consumption, impaired but still usable for certain purposes such as animal feeding, or completely spoilt and requiring immediate safe disposal. The condition of containers, particularly those made of perishable or breakable materials such as cardboard, paper, sacking, or glass, offers a preliminary guide for this selection; a more thorough examination should follow. The sale of damaged food must be prevented, and the full co-operation of food retailers and distributors must be ensured.

Floods in particular are responsible for widespread spoilage and contamination of food. Flood water carries filth and pathogenic organisms from the ground surface, sewage systems, cesspools, and barnyards. To prevent typhoid fever and other gastro-intestinal infections, all foods that have been in contact with flood water and not contained in hermetically sealed tins must be destroyed. Even food in glass jars and bottles is suspect, as contamination may seep through crown caps and screw tops. Intact but soiled tins must be cleaned and disinfected before opening.

Food supplied from outside the disaster area by official agencies and voluntary relief societies must come from reliable sources, and should be inspected for deterioration during transit. It is preferable that the first supplies consist of individual rations of pre-cooked assorted foods in sealed watertight wrappings or boxes, for rapid distribution and immediate use during the period when normal cooking and feeding services are impracticable. The composition of these emergency rations should be selected on the basis of concentration, nutritive value, palatability, and keeping properties.

Immediately following the disaster cooked food will be distributed in individual packs or through mobile canteen units, but as soon as possible the feeding programme should develop along two main lines: (a) the provision of food for those who have facilities for preparing and cooking their meals under their own initiative and responsibility, and (b) the arrangement by the relief organization of mass feeding services for those who lack such facilities.

#### *Mass feeding services*

Unless proper sanitary measures are applied to the storage, preparation, and distribution of food under emergency conditions, mass feeding will be a constant danger to health. Food is easily contaminated and has the ability to support the growth of pathogenic organisms. Moreover, other services connected with the protection of food, namely water supply, waste disposal and vector control, are carried out in an improvised manner during emergencies. Conditions therefore favour the outbreak of food-borne diseases, and the consequences of such an outbreak could be extremely grave because the medical and nursing services, which might already be short-staffed and swamped with urgent cases, would not be able to cope with the situation. These considerations show clearly the necessity for the proper planning and operation of food sanitation programmes in emergencies.

The provision of food is not the responsibility of health authorities. However, the environmental health officials should know the quantities and types of food involved, the lines of supply, and the means of distribution so that they can devise and apply the proper sanitary safeguards. The first move, therefore, is to bring together all the health, supply, welfare, and

other officials involved in the provision of food in order to develop a reasonable plan for the sanitary supervision of food supplies and installations.

The measures that can be applied in order to ensure good food sanitation include:

- (1) quality control of incoming food in order to detect spoilage and contamination;
- (2) quality control of water supplied to food-preparing centres;
- (3) control of insects and rodents in stores, kitchens, and feeding centres;
- (4) provision for the proper storage and cooking of food;
- (5) provision for the proper disposal of solid and liquid wastes;
- (6) provision for the proper washing and sanitizing of utensils;
- (7) supervision of food preparation;
- (8) supervision of food serving;
- (9) supervision of the cleaning of premises where foods are handled;
- (10) management of food-handling personnel, which includes (a) health checks, (b) training, (c) ensuring that numbers are adequate, and (d) provision of adequate sanitary facilities.

There are some areas that need special attention and supervision by sanitation personnel. They are:

- (1) vehicles for food transport;
- (2) food storage;
- (3) mass feeding centres, including kitchens;
- (4) emergency hospitals;
- (5) milk distribution centres.

Some important points to be borne in mind in the organization of mass feeding centres are listed below:

(1) The location and layout of field centres for mass feeding should be selected and arranged in consultation with responsible sanitation officers so as to ensure reasonable sanitary safeguards. Whenever possible, use should be made of existing buildings, such as restaurants, hotel dining rooms, schools, public assembly halls, and churches, which offer suitable conditions for maintaining a satisfactory standard of cleanliness at all times and for preventing the invasion of rodents and insects.

(2) Only potable water may be used in feeding premises. Where there is no piped supply, water must be transported, stored, and handled in a sanitary manner.

(3) A sufficient number of basins, each with soap, nail brush and a clean towel, must be provided exclusively for the use of food handlers.

(4) Separate basins must be provided for washing all sorts of eating and cooking utensils. Before washing, any grease or food scraps on the utensils should be scraped into a refuse bin; the utensils are then washed in a basin with hot water and detergent, laid on wire baskets or trays, and immersed in boiling water for disinfection for 5 minutes. An alternative method of disinfecting utensils already washed is to immerse them in a sterilizing solution, preferably hot, of either chlorine (100 mg/litre for 30 seconds) or quaternary ammonium compounds (200 mg/litre for 2 min). Wiping dry is unnecessary and undesirable, the baskets or trays being laid down for drying in a dust-free place.

(5) Another basin should be provided for washing all fruits and vegetables before cooking. The serving of raw vegetables and soft-skinned fruits should be forbidden, unless this is unavoidable for dietary reasons; in such cases the vegetables and fruits must be thoroughly washed, immersed in a chlorine solution (100 mg/litre for 3 min), and rinsed until the smell of chlorine disappears.

(6) Safe excreta disposal installations for the staff should be provided close to the mass feeding centre, it being assumed that people eating at the feeding centre can make use of the general facilities. Toilets and latrines must be kept in the best possible state of cleanliness at all times.

(7) Liquid wastes from kitchens, if not discharged to public sewers, should be disposed of by other sanitary methods, such as a soakage pit or covered cesspool. A grease trap or strainer must always be provided and properly maintained to prevent choking.

(8) Solid wastes from kitchens must be deposited immediately in refuse bins (garbage cans), such as described on page 68. No filled bins may remain in preparation and cooking areas; they must be tightly covered and removed outside for collection and disposal.

(9) A refuse removal service must be promptly started, as proper collection and disposal obviates many problems, particularly fly breeding, rodent invasion and fire risks. When this service is impracticable an attempt must be made to separate refuse into:

(a) *Inert refuse*: mainly bottles and tins. When intact they could be salvaged; disaster victims can find many uses for tins. If damaged, they should be crushed or flattened and buried.

(b) *Combustible refuse*: mainly wrappings, bags, boxes, etc. They could be burned in a kitchen incinerator.

(c) *Putrescible refuse*: food wastes of all kinds. When there is sufficient combustible refuse this could be burned in the incinerator; otherwise it must be buried with inert refuse.

(10) Basins, tables, chopping blocks, carving boards and all other furniture and equipment must be kept as clean as possible when in use and thoroughly cleaned after each meal.

(11) Only food that is to be used the same day may be kept in the kitchen. Food not in the process of preparation or cooking must be kept in fly-proof cupboards and containers.

(12) Where refrigeration facilities are non-existent or inadequate, perishable foods should be bought on a daily basis and cooked and served as soon as possible. The slaughtering of animals for consumption the same day could be considered when a veterinarian or a qualified meat inspector is available.

(13) Condensed or powdered milk must be reconstituted with potable water only, and under the best possible sanitary conditions. If natural milk is available for infants and hospital patients, it must be boiled before use.

(14) An adequate supply of detergents, disinfectants, brushes, cloths, brooms, and other housekeeping necessities must be provided.

(15) Disposable plates, cups, etc. may be used in mass feeding centres and especially when disaster victims are on the march. Common drinking cups must not be tolerated.

The measures applied to maintain a sanitary environment in the feeding centres and to protect food from contact with contaminated matter will be useless if the cleanliness and health of the personnel of feeding centres are disregarded. Food handlers with dirty hands and clothing, unhygienic and careless habits, and active or latent communicable disease are just as often responsible for food contamination as flies, soiled utensils, and other unsanitary conditions in kitchens and eating areas.

A disaster may result in a shortage of skilled personnel for feeding centres, and it may be necessary to rely upon voluntary help to supplement the staff. However, no one suffering from or carrying any communicable disease may be employed for this service. Persons with boils, sores, infected wounds, sore throats or acute respiratory infections must be rejected. Medical examination of all food handlers should be established as early as possible.

The selection of voluntary helpers should be based on health, personal cleanliness and hygiene, and previous experience. To attain a satisfactory standard of personal and environmental hygiene, in-service training and close supervision are essential. Instruction in proper sanitary practices should be adapted to the improvised installations. Lifelong habits are difficult to change; the only way to ensure that the instruction is put into practice is through frequent inspection and constant vigilance.

If there are not enough trained sanitary workers for supervising feeding centres, suitable persons could, after an orientation course, assist the sanitation officers by inspecting the food premises and reporting any deficiency or fault.

The need for cleanliness at all times must be stressed. It is most important to teach all food handlers, including waiters, to wash their hands before starting work, after going to the toilet, and as often as may be necessary to remove soil and contamination; to refrain from touching unnecessarily any food or the food-contact surfaces of any utensils used for eating and drinking; to refrain from sneezing and coughing over or close to food; to wear outer garments that are for use exclusively while preparing, cooking, or serving food, keep these aprons and gowns as clean as possible, and change them when they become soiled; and to abstain from smoking in areas for preparing and cooking food. All personnel in mass feeding centres must understand and apply the basic principles of food sanitation. Realistic and clear instructions, adapted to the emergency conditions, should be posted at all strategic points to remind the staff constantly of their obligations. Illustrated posters are most helpful, and are essential when some of the staff are illiterate.

### **Vermin control**

Conditions immediately after a disaster favour a rapid increase in the population of insects and rodents. The immediate cause may be the breakdown of sanitary services, such as collection and disposal of refuse, and the subsequent production of sites suitable for extensive breeding and harbouring of vermin. The accommodation of large numbers of people in temporary shelters under such conditions will expose them to diseases carried by insects and rodents.

Opportunities and facilities for personal cleanliness may be extremely limited in temporary shelters; carriers of infectious diseases and persons infested with vermin may be in close contact with others free from infection. This situation, probably already complicated by somewhat primitive sanitary installations and services, creates potential hazards that demand attention and action.

The movement of people to a new place often exposes them to insects and to such diseases as typhus, malaria, and plague. Flies, fleas, lice, mites, mosquitos, ticks, and rodents are disease vectors that develop rapidly in an uncontrolled environment.

The insects likely to cause trouble, annoyance, or localized infection include chiggers, gnats, bedbugs, mosquitos, and cockroaches. In some areas, disaster victims will be exposed to poisonous reptiles, spiders, and other creatures; while these endanger only the specific individual in contact with them, attack may have a demoralizing effect on people who because of the circumstances are already inclined to hysteria.

The vectors most likely to be present in encampments and temporary shelters and the main diseases they may transmit through biting, skin infection, and pollution of food and water are listed below:



<i>Vector</i>	<i>Main diseases</i>
Mosquitos	Malaria, yellow fever, dengue, viral encephalitis, filariasis
Houseflies	Diarrhoea, dysentery, conjunctivitis, typhoid fever
Cockroaches	Diarrhoea, dysentery, salmonellosis
Lice	Endemic typhus, pediculosis, relapsing fever, trench fever, skin irritation
Bedbugs	Severe skin inflammation
Cone-nosed bugs	Chagas' disease
Ticks	Rickettsial fever, tularaemia, relapsing fever, viral encephalitis
Rodent mites	Rickettsialpox, scrub typhus
Rodent fleas	Bubonic plague, endemic typhus
Rodents	Rat-bite fever, leptospirosis, salmonellosis, melioidosis

Vector control programmes should be planned so as to cope with two distinct situations:

(1) The initial or emergency phase immediately following the disaster, when control work should concentrate on the destruction, by a physical or chemical process, of vermin on persons, their clothing, bedding, and other belongings, and on domestic animals. An emergency sanitation team should be available from the beginning for carrying out this disinfection.

(2) The period after the emergency has subsided, when control work should be directed towards proper food sanitation, safe disposal of wastes, including drainage, and general and personal cleanliness.

The direct attack on insects and their breeding and harbouring places should be carried out throughout the post-disaster period.

### *Insects*

The greatest attention should be paid to the cleanliness of victims and their belongings in order to reduce the incipient hazards of infestation, infection, dermatitis, and other personal afflictions. Arrangements for washing are discussed in the section on "Miscellaneous installations" (see pages 85-86).

Louse proliferation is to be expected in overcrowded temporary shelters and encampments; under such conditions dusting with an insecticidal powder should be an established routine for all refugees arriving at the reception centre or camp. *If needed, voluntary helpers should be trained in dusting operations.* The efficacy of the insecticide should be tested in advance. At encampments of 500 persons or more, the disinfection station should be a compactly planned unit, with suitable quarters for quick and efficient treatment. This unit should also be equipped for emergency disinfection of clothing, bedding and other articles, tents, and living quarters. The teams operating from a disinfection unit should be able to cover several neighbouring camps. Some methods of disinfection and disinfection are described in the section on "Miscellaneous installations" (see pages 86-88).

Preliminary surveys should be made in camping areas to determine the number and extent of sites where insects and rodents may breed or harbour. These sites should be mapped to indicate the places where control measures are required. There are 3 types of area on which it is particularly important to obtain information:

(1) *Mosquito-breeding areas.* Breeding sites may be detected from larval collection and inspection. Suitable data sheets and maps should be used to record pertinent information. The trapping of adult mosquitos will give quantitative information on their number and distribution and on the effectiveness of control measures.

(2) *Fly-breeding areas.* Inspection for fly breeding should include all refuse disposal sites, animal yards and shelters, surface toilets, heaps of uncovered garbage, and places where abattoir wastes or any other decaying organic material may accumulate. Climate and season of the year are important factors in evaluating the fly-breeding potential. Temperatures above 20°C are conducive to the rapid increase of the fly population. Where experienced personnel are available, routine determination of fly densities may serve to assess the effectiveness of control measures.

(3) *Rodent harbourages.* A rodent control programme should be preceded by a preliminary survey to determine the extent and location of rodent infestation, the probability of the occurrence of rat-and-flea-borne or mice-and-mite-borne disease, and the possibility of food and property being spoilt and of people in temporary shelters being bitten. An effective programme requires recognition of the prevailing species.

Vermin control should follow a definite plan and programme. Special teams should be organized for this purpose. The team leader should be a sanitarian with adequate knowledge and experience in the field of vector control. The malaria control organization, the national institute of health and other bodies concerned with vector control and research must be consulted as to the presence in the disaster area of vectors resistant to pesticides. In its seventeenth report, the WHO Expert Committee on Insecticides<sup>1</sup> made a number of important recommendations.

To obtain maximum control of an insect or rodent, the operator should have some knowledge of the biology and ecology of the species with which he is concerned and experience with the various procedures and pesticides available. Non-selective application of pesticides by routine methods based on a single technique or chemical may lead to unsatisfactory results. For example, the application of insecticidal fogs before dusk is often unsuccessful in controlling certain species of mosquitos, whereas the same treatment at dusk or shortly thereafter gives excellent results. Likewise fogging under unfavourable weather conditions can be valueless. In some countries, the species of anopheline are semi-domestic in their habits (for example, *Anopheles sergenti* in Israel and Jordan) and residual treatment of homes is only partially effective in interrupting malaria trans-

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<sup>1</sup> WHO Expert Committee on Insecticides (1970) *Insecticide resistance and vector control: Seventeenth report*, Geneva (*Wld Hlth Org. techn. Rep. Ser.*, No. 443), pp. 167-168.

mission. However, in the same countries a domestic species (*An. sacharovi*) has been almost completely eliminated by the same operations. A similar situation prevails in Africa where *An. funestus* has disappeared in areas subject to residual applications. In other areas, where the outdoor biting habits of the anopheline mosquito decrease the efficiency of residual treatments in dwellings, such approaches as larviciding may be of importance, particularly where the mosquito breeding is reduced or confined to limited habitats during certain seasons of the year (for example, *An. albimanus* in stream beds in Central America during the dry season). Where measures are to be directed against both larvae and adults, it is advisable to use different chemicals for each type of treatment to reduce the possibility of the species developing resistance to the insecticide.

The efficacy of the chemical control measures is markedly influenced by a number of other factors: (a) the species involved, (b) the efficiency of the application, (c) the type of formulation and application, (d) the nature of the surface to which the formulation is applied, (e) the stability and potency of the pesticide, (f) the biotic potential of the species, and (g) the management of the control programme.

It is emphasized that all control procedures, if they are to be successful, must be adequately supervised by competent personnel.

### 1. Mosquitos

In areas where mosquito-borne diseases are endemic, initial control should be directed against adult mosquitos and their breeding places.

*Adult control.* The interior surfaces of occupied dwellings, outbuildings, culverts and other resting places should be sprayed with a liquid mixture containing DDT, chlordane, or some other suitable insecticide. Tent encampments may be treated at dusk with insecticidal fogs produced by power space-sprayers.

*Larviciding.* The method to be used will depend on the location, size, and accessibility of the mosquito-breeding area. Where breeding areas are accessible and of less than 5 hectares, larviciding operations from the shore using either hand-operated or power sprayers will prove effective. For areas of over 10 hectares, motor vehicles or boats with power-spraying equipment will prove more efficient. For extensive breeding areas, where control measures are urgent, the use of aircraft with spray equipment may be required.

### 2. Flies

*Control by sanitation.* The most effective method of fly control is the practice of good sanitation in the disaster area. This includes the sanitary storage, collection, and disposal of organic wastes. If sanitary landfill or incineration is not possible, wastes should be dumped at suitable sites located at least 5 km from any densely populated area. Stockyards and cattle shelters should be inspected frequently, at least once a week, to ensure proper disposal of wastes. Manure may be held in fly-proof bins, spread in thin layers over a field, or buried under 30 cm of compacted earth. Only sanitary latrines or privies should be permitted in areas not served by sewerage systems. In all other potential fly-breeding places, such as

kitchens, eating places, abattoirs, and dairies, cleanliness should be practised to discourage flies and other vermin.

*Control by chemical treatment.* Flies may be controlled by residual spraying of the areas where they breed and rest. Where vehicles are available, the use of power-spraying equipment is desirable. Space-spraying machines are very effective in emergency fly control. Some hand-sprayers may be required to reach areas inaccessible to the machine (the inside of houses, privies, and other buildings). Insecticides, particularly dieldrin, should not be used in privy pits, since such use may result in an increase of flies.

*Screening.* Hospitals, foodstores, mass feeding centres, kitchens milk distribution centres, and similar places should be adequately screened with wire or plastic mesh to prevent the entrance of flies not eliminated by chemical control.

### 3. Other insects

Cockroaches and ants may infest kitchens, mess halls, and toilets. Their control is primarily a matter of cleanliness. A 5% chlordane dust or spray, used behind shelves and skirting boards, in crevices, under the tops of tables, sinks, and stoves, around garbage cans, on latrine floors, and similar places, will also prove effective in holding these insects in check. Lice, fleas, and mites may be controlled by applying 10% DDT powder to the hair and inner and outer clothing of individuals. Several applications should be made at weekly intervals. Living quarters in camps and temporary shelters may be fumigated under competent supervision.

### *Rodents*

When there is imminent danger of an outbreak of rodent-borne disease, emergency action should be taken immediately. The following measures of control are recommended:

(1) Dust rat-runs with 10% DDT or some other tested insecticidal powder to eliminate first the ectoparasites in the rat. This is extremely important if there is a plague outbreak or where plague is endemic.

(2) Extend dusting to other areas in the community where rats and fleas are found.

(3) Conduct mass poisoning of rats at dumps and harbourages in the proximity of the populated area.

Where there is no imminent danger of outbreaks of rodent-borne disease, the following programme is suggested:

(1) A master map should be prepared, indicating the sections where rat control is required. A well-trained sanitarian should be placed in charge, and provided with sufficient personnel and equipment to meet the requirements. The area should be divided into sections, each covered by a crew for dusting and poisoning.

- (2) Reduce rat populations with poison.
- (3) Extend and intensify the collection and removal of refuse within 2 km of the populated area. Enforce proper storage and sanitary disposal methods to deprive rats of food.
- (4) If the area is at or close to a port, enforce port regulations on rat control.

Information on recommended insecticides and rodenticides, concentrations, dosages, and the preparation and application of formulations is given in Annex 9.

#### *Health hazards and precautions*

All pesticides in current use are to some degree toxic to man. Persons preparing pesticides, or applying spray or powder, should take care to avoid inhaling the dust, sprays or fumes, and to prevent skin contact as far as possible. Spray operators should wear protective clothing, such as rubber gloves, broad-brimmed hats and overalls. Insecticides spilled on the body or hands should be removed immediately with soap and water. Unusual signs of nervousness, dermatitis, and loss of appetite should be reported immediately; a medical examination should follow the appearance of these symptoms. Precautions that should be taken when applying pesticides are described in the seventeenth report of the WHO Expert Committee on Insecticides.<sup>1</sup>

#### **Mortuary service and burial of the dead**

Supervision of the emergency mortuary service is the responsibility of the public health service. It is likely that, apart from the medical examination of the dead, the supervisory work will be carried out by sanitation personnel. In any case, this supervision is necessary, especially in outbreaks of epidemics. The work to be carried out consists of:

- (1) *Removal.* The removal of dead bodies from the scene of disaster is not the responsibility of sanitation personnel, but they often co-operate with other workers as the situation demands. Quick and quiet removal of bodies from public view plays an important role in maintaining morale.
- (2) *Morgue.* This should have four sections: a reception room, a viewing chamber, a storage chamber for bodies not suitable for viewing, and a room for records and for storage of personal effects. In some severe emergencies it may be necessary to bypass the morgue.
- (3) *Establishment of legal proof of death.* This is the responsibility of the medical examiner who issues the death certificate.
- (4) *Identification of the dead.* Efforts should be made to identify dead bodies or at least to obtain all possible information.

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<sup>1</sup> WHO Expert Committee on Insecticides (1970) *Seventeenth Report*, Geneva (*Wld Hlth Org. techn. Rep. Ser.*, No. 443), pp. 258-267.

(5) *Preparation of an official record of death.* An identity tag should be affixed to the body and all available information recorded in a special book.

(6) *Final disposal of the body.* Mass burials in a common grave should be avoided. The location of graves should be charted on maps and identified by tag numbers.

(7) *Return of valuable personal effects.* The next of kin should receive the valuable personal effects of the dead. In the event of epidemics, personal belongings should be disinfected before they are returned.

The following items are needed for the mortuary service: stretchers, leather gloves, rubber gloves, overalls, boots, caps, soap and disinfectants, cotton cloth, picks and shovels. Heavy earth-moving machines and trucks may also be required.

Precautions should be taken always in handling dead bodies, but particularly in cases of death from a contagious disease. In epidemics, strict sanitary supervision should be maintained at all stages of handling the dead; the mortuary personnel should have special working clothes and at the end of a day's work they should wash themselves thoroughly with a disinfectant soap.

### **Miscellaneous installations**

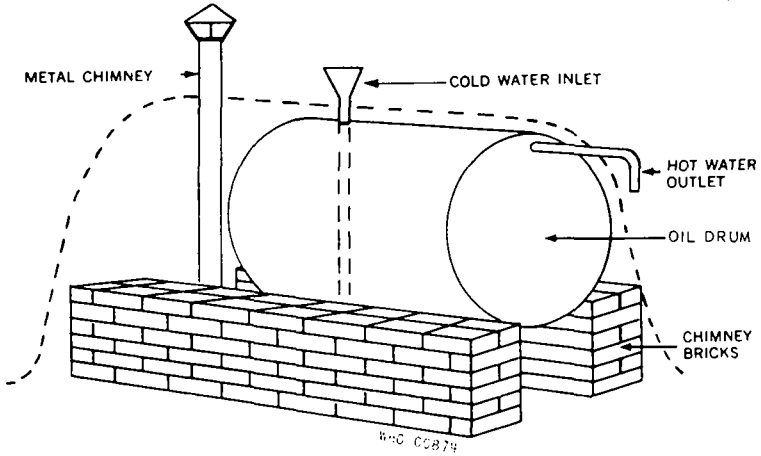
In temporary shelters and camps, communal facilities for maintaining personal cleanliness should be provided. These may include showers, washrooms, laundries, and disinfestation and disinfection rooms. They will help to prevent skin diseases and infestations that lead to vector-borne diseases: disinfection rooms are necessary for halting the spread of infectious disease transmitted through fomites. The proper operation and maintenance of these services depends on constant supervision by sanitation personnel.

#### *Baths and showers*

Showers are preferable to baths both for sanitary reasons and to save water. One shower head should be provided for every 100 persons. Bath registers or bath tickets may be used for ascertaining that everybody in the camp bathes at least once a week. In hot climates, cold water should be sufficient. If hot water is provided, 20 litres should be supplied for each bath; over-all consumption of water for bathing should be calculated on the basis of 30–35 litres per person per week. The use of common towels should not be permitted unless arrangements are made for washing and disinfecting them after each use. For both hygienic and economic reasons, communal baths should be located near the disinfestation and disinfection rooms. Proper arrangements should be made for the disposal of waste water from baths. Temporary shower baths can be set up within a reasonably short time. Fig. 31 and 32 show a quick method of providing

temporary water heaters and showers on a small scale. More permanent and bigger installations should be established at long-term camps. Bath rail wagons and trucks are very suitable for use in disaster operations.

FIG. 31. PUT-AND-TAKE WATER HEATER



Adapted from: Canada, Department of National Health and Welfare (1967) *Environmental health in disaster*, Ottawa, p. 91.

This heater can be made from a 200-litre oil drum. The cold water inlet, consisting of a pipe 4 cm in diameter, extends to approximately 5 cm from the bottom of the drum. The hot water outlet is placed as close as possible to the rim so that no hot water is lost by overflow. The hot water in the drum is recovered by pouring in cold water; this forces the hot water upwards and through the outlet. The drum is placed on chimney bricks, built up approximately 6 bricks high, and a metal chimney is fitted at the rear of the drum. A water-and-oil flash fire is used, and the bricks act as a fire box to keep down ventilation. The entire heater can be covered by turf.

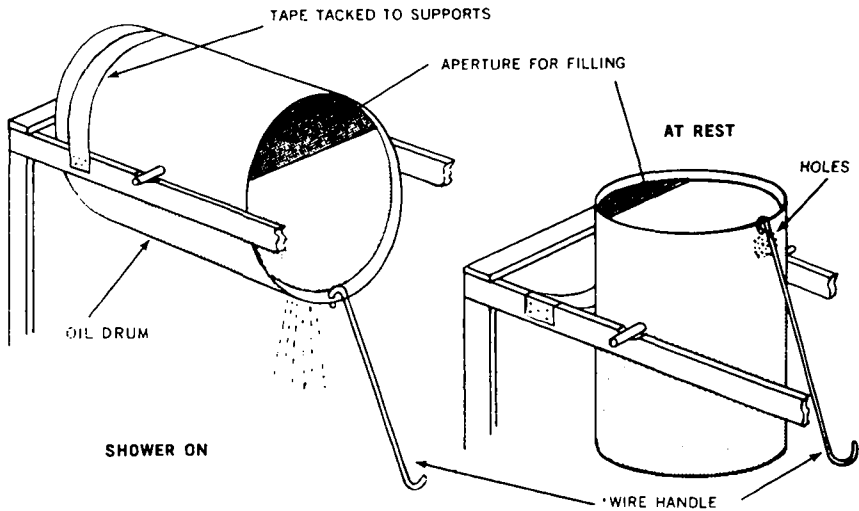
### *Laundries*

In temporary encampments people may be expected to wash their clothes in plastic or iron tubs. In long-term camps, however, it becomes necessary to provide communal laundries. Where disinfection rooms are needed, these and the laundries should be housed together. Whenever possible, hot water should be provided. One washing stand for every 100 persons is recommended. It will be necessary to establish a schedule for the use of laundries on a family basis, otherwise they will be crowded at some times and left idle at others. Proper drainage and grease and soap traps should be provided for the waste water.

### *Disinfection and disinfestation*

Disinfection is the process of destroying disease germs. Disinfestation is the process of removing or killing insects, their eggs, and other vermin that transmit disease or cause annoyance. Disinfection methods will be effective for disinfestation, but the reverse does not hold true. In practice, disinfestation is more often used than disinfection. The methods employed in disinfestation will destroy vermin but will not necessarily kill the disease

FIG. 32. IMPROVISED SHOWER



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Adapted from: Canada, Department of National Health and Welfare (1967) *Environmental health in disaster*, Ottawa, p. 92.

This shower can be made quite simply from a 20-litre oil drum, suspended from the crutch of a tree or improvised supports. A duckboard over a soakage pit should be provided for each shower.

germs carried by vermin such as lice; when there is any risk that vermin may cause an epidemic, therefore, it is safer to employ disinfection.

Effective disinfection requires trained personnel, as failure to carry out properly any of the various steps of the disinfection process will defeat the purpose. Well-trained and experienced sanitarians should therefore be in charge of disinfection and disinfestation operations.

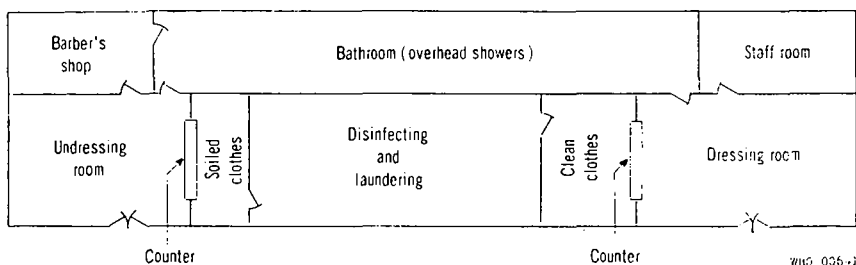
Methods used in disinfection and disinfestation involve the use of physical agents such as ultra-violet light, dry heat, boiling water, and steam, or chemical agents such as sulfur dioxide, ethylene oxide, formaldehyde, formol, cresol, phenol, and carbolic acid. Some of these agents are dangerous, and should only be used under expert supervision.

The area or building used for disinfection should be divided into a "dirty" side for the receipt of infected articles and a "clean" side for the distribution of disinfected articles; the only communication between these two sides should be through a disinfection and laundering room (for clothing, etc.) or through a bathroom (for persons). The layout of a combined bathing and disinfesting unit is shown in Fig. 33. Modifications can be made to suit local requirements.

Arrangements should be made on the "dirty" side for disinfecting the vehicles used for the transport of infected materials; personnel employed in handling infected materials must be suitably protected against infection.



FIG. 33. SUGGESTED LAYOUT FOR A COMBINED BATHING AND DISINFECTION UNIT



On the "clean" side, storage space should be available for disinfected articles.

All articles not likely to be damaged are disinfected by steam. The steam flow can be either downward or upward. Leather goods, clothing with leather facings or strappings, furs, rubber, and other materials that may be spoiled by steam, are sprayed with a 5% formol solution.

The layout of a disinfection unit is the same as that of a disinfection unit. Disinfection will not be effective unless infested individuals have previously been segregated; otherwise the entire camp population will have to be disinfected.

#### *Abattoir*

Because of the absence or shortage of refrigeration equipment, it often becomes necessary to make simple slaughtering arrangements in camps. The site should be secluded but kept under close supervision. The floor should be of concrete or asphalt, sloping towards a central drain provided with a trap or strainer to collect solids. The liquid waste may be discharged into a seepage pit. Ample water should be provided for washing. Hooks hung on a horizontal beam at a height of about 2 m, supported by 2 vertical poles, provide the means for the skinning of carcasses.

Offal, bones, and other solid wastes should be buried, or burnt in a closed incinerator. In the case of burial, a series of pits should be dug and the offal covered with at least 90 cm of earth, thoroughly treated with heavy oil, and well compacted.

#### **Education of disaster victims in sanitation**

Experience has shown that sanitary installations provided as part of the relief work after disasters do not always fulfil their purpose because they are either misused or not sufficiently used. Among the most important reasons for this lack of appreciation among disaster victims are: (a) the psychological effect of the disaster, manifested mainly in an apathetic attitude; (b) the victims' low living standard before the disaster, and

(c) their ignorance as to the use and maintenance of the installations provided. In itself, therefore, the provision of sanitary installations is not enough to solve the problem: the people must use them properly and frequently so that an adequate level of personal cleanliness and of environmental hygiene is attained. It is therefore the responsibility of all environmental health workers to participate actively in educating the disaster-stricken people to use the sanitary installations properly, to comply with the rules of personal hygiene, and to safeguard the health of the community.

A number of points concerning education should be borne in mind:

(1) To be successful, education should be based on the trust and collaboration of the people. To gain their confidence, it is extremely important that the health worker should have a sympathetic disposition: an authoritative attitude is detrimental.

(2) The sanitary installations used should be of a type easily understood by the people. Simple and accessible solutions can generally be devised without sacrificing the basic principles of sanitation. If a complex installation is unavoidable, patient and constant instruction is necessary to make it understood and ensure that it is used properly.

(3) On-the-spot education is most effective.

(4) In relief situations of short duration, there is not enough time to start educational processes and the proper operation of sanitary installations depends on effective inspection. Young people from the afflicted area and from welfare agencies, such as the national Red Cross, should be used to help professional inspectors. Systematic and regular inspections must be established.

(5) Media for mass education have proved their value in emergencies.

The areas in which sanitation education is needed include:

- (1) avoidance of using contaminated or doubtful water;
  - (2) avoidance of wasting water;
  - (3) co-operation in distributing water;
  - (4) co-operation in protecting the water supply system;
  - (5) co-operation in using the excreta disposal installations properly and in keeping them clean;
  - (6) avoidance of scattering refuse and observance of rules for its proper collection;
  - (7) co-operation in reducing insect populations;
  - (8) cleanliness of the shelters and camp;
  - (9) cleanliness of food containers, dishes, utensils, etc.;
  - (10) observance of personal hygiene rules (body and clothing);
  - (11) proper collection of manure;
  - (12) participation in community clean-up work.
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## 6. REHABILITATION AND RECONSTRUCTION

This Guide would not be complete without a brief reference to rehabilitation and reconstruction work after the disaster. Most of the specialized agencies of the United Nations have indicated their willingness to assist in this final phase of disaster relief. Since the planning for reconstruction starts immediately after the disaster and many relief services can be organized so that they extend to the rehabilitation stage, it is important to include measures for the reconstruction of the damaged area in the national disaster plan. It should be borne in mind that the reconstruction of a devastated area is not limited to the erection of new buildings, but embraces its whole redevelopment. Planners should therefore pay due attention to industry, agriculture, town planning, and all other socio-economic aspects of reconstruction.

The authority responsible for rehabilitation should:

(1) make policies and decisions (financial, legal, technical, operational, etc.); this involves the work of government ministries, local authorities, institutions, welfare societies, and any international or foreign organizations concerned;

- (2) establish priorities;
- (3) prepare plans (regional, urban, etc.);
- (4) exercise economic and technical control of labour and materials;
- (5) appraise the effects of the disaster on structures; revise building codes; introduce technical control of buildings and facilities;
- (6) reconstruct public works and buildings;
- (7) execute programmes for replacing destroyed housing;
- (8) provide for the assessment, registration, and selection of houses that can be restored.

In order to plan for reconstruction, statistical information on the following points is required:

- (1) number of people concerned, their geographical distribution, age groups, etc.;
- (2) number of houses destroyed and the standard of housing before the disaster;
- (3) available manpower, materials, equipment, and financial resources;
- (4) rent levels; the source and amount of funds invested in housing and public utilities;

The housing policy should specify:

- (1) what agencies should undertake housing;
- (2) whether new housing should be built on the previous site or elsewhere;
- (3) whether particular groups of families should be given special consideration;
- (4) the standards of construction for living accommodation;
- (5) whether changes should be made in laws governing landlord-tenant relations;
- (6) whether it is necessary to introduce new industries and techniques, initiate training of building workers, etc.

As reconstruction is concerned with the restoration of the residential environment, it is pertinent to quote the definition of the residential environment adopted by the WHO Expert Committee on the Public Health Aspects of Housing: "the physical structure that man uses for shelter and the environs of that structure including all necessary services, facilities, equipment and devices needed or desired for the physical and mental health and the social well-being of the family and individual".<sup>1</sup>

In the reconstruction of urban disaster areas, due attention should also be paid to new concepts of town planning. Town planning is the systematic preparation of recommendations concerning the policies and courses of action needed to achieve specified objectives in the life of urban communities. The vital issues in urban planning are:

- (1) capital programming;
- (2) public participation;
- (3) over-all urban form or structure;
- (4) redevelopment;
- (5) open spaces.

The great changes involved in redevelopment have a strong effect on environmental conditions, and governments are therefore urged to include sanitary engineers in their planning teams for the restoration of areas devastated by disasters. Sanitary engineers should realize that they have a valuable contribution to make not only during the relief phase but throughout the rehabilitation and reconstruction stages until all traces of the disaster have been eliminated.

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<sup>1</sup> *Wld Hlth Org. Techn. Rep. Ser.*, 1961, No. 225.



## Annex 1

### SPECIMEN TEXT FOR A PAMPHLET ON EMERGENCY SANITATION AT HOME \*

Many public services could be put out of action by natural disasters. If the water utility serving your community were damaged, your household water supply would be cut off until repairs could be made. If sewers were broken, it would not be possible to dispose of human wastes by the usual methods. The lack of a garbage collection and disposal service would encourage the increase of rats, flies and other disease-carrying agents. It would be hard to maintain the usual flow of food supplies.

Impure water and unsafe food produce disease. Garbage and human wastes can help to spread disease; a dirty home and an unclean body have the same effect. It is therefore important that families take care of themselves until the situation becomes normal or help is received. To do so, simple sanitation rules should be followed at home. A few simple steps that can protect families are described below.

(1) Drink only water or other liquids that you know are safe. Store enough water for the family during the warning period.

(2) Know where to find the valve that controls the water supply to your home, so that you can shut off the supply if necessary. Try the valve to make sure that it works freely. If a tool, such as a wrench, is needed to operate the valve, be sure you know where to lay your hands on one quickly in an emergency. Learn where to get water for emergency drinking, cooking and washing if your outside supply fails.

(3) Be prepared to purify water for drinking purposes in your own home. There are various methods that can be used:

*Boiling* : Water can be made suitable for drinking purposes by boiling for 5–10 minutes. This will destroy the germs.

*Chlorination* : Bleach solutions of 5% strength may be available. Add 1 drop of the bleach solution for each litre of clear water (3 drops for turbid water). After adding the appropriate amount of bleach, stir and allow the water to stand for 30 minutes. A distinct taste or smell of chlorine, which is the sign of safety, should be detected; if not, add a few more drops, wait for 15 minutes and taste again.

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\* Based on *Emergency sanitation at home*, a pamphlet issued by the US Office of Civil Defense, 1963.

*Purification tablets* : Tablets that release iodine may be used safely to purify water. Usually one tablet is enough for one litre of clear water; for turbid water two tablets should be used.

*Tincture of iodine* : Ordinary household tincture of iodine can be used to purify water. Add 2–3 drops for each litre of clear water (8–10 drops for turbid water), mix, and allow to stand for 30 minutes.

(4) Eat only safe foods prepared under safe conditions. Keep a 2-week supply on hand, and replace the things you use.

(5) Avoid using foods or liquids that might be contaminated.

(6) Provide for the disposal of human wastes in covered containers in case flush toilets are inaccessible or not working: learn how to make soil bags.

(7) Bury excreta and your garbage under at least 30 cm of compacted earth.

(8) Listen to and observe the instructions of the health authorities.

## Annex 2

### RELATIONS BETWEEN THE NATIONAL RELIEF COMMITTEE AND OTHER AGENCIES

The importance of establishing a central body to co-ordinate relief work is discussed in section 4. The chief environmental health officer has to collaborate with many other officials involved in relief operations. He must therefore understand the operation of the central command post on which he has to depend for policies, information, administrative procedures, communications, transport, and many other matters. He needs to be a person of strong personality, resourcefulness, and ingenuity, who will make his voice heard in questions of policy-making. The success of environmental health operations will largely depend on his relations with the leading officials of the central relief organization. Since there is little time for establishing effective ties with them after the disaster, the foundations should be laid during the period of pre-disaster planning. Personal contact and friendly relations with the directors of relief operations would make things run more smoothly.

#### **Other sections of the health department**

##### *Preventive health services*

Proper co-ordination of sanitation work with other preventive measures is essential, especially in fighting active epidemics or in preventing their outbreak. In vast regions affected by an epidemic, the organization of mobile teams consisting essentially of medical, nursing and sanitation personnel will permit more effective use of the available staff and vehicles. However, care should be taken in organizing special teams for specific purposes; leadership should be given by the member of the team whose discipline is most important in the circumstances. Sanitation personnel must not be employed for other work.

##### *Medical care*

First-aid stations and field hospitals have their own sanitation problems, and if the necessary sanitary precautions are neglected they may become sources of infection. The most important activities in which sanitation personnel should co-operate with workers in medical care are:



(1) provision of safe and ample supply of water for hospitals and first-aid stations;

(2) provision of means for the proper disposal of sewage, waste water, and solid wastes, especially soiled cotton, dressings, etc.; dressings must be destroyed, preferably by incineration;

(3) supervision of the sanitation of the food service in field hospitals;

(4) supervision of the means and procedures for washing, disinfection, and disinfestation.

### *Health education*

There should be close co-operation between environmental health and health education personnel at all times. They may jointly prepare information material for press releases, conferences, radio and television broadcasts, mobile health education units, posters, pamphlets, etc. Such material should be so designed as to stimulate hygienic habits and obtain the public collaboration that is essential for the proper use of sanitary installations.

### *Administrative services*

Good understanding is necessary with the personnel, supplies, transport, finance, and similar services. It is emphasized that the efficiency of administrative services and the success of emergency operations depends on good logistics.

## **National Red Cross Society<sup>1</sup>**

The Red Cross societies are among the most active of relief agencies. Their responsibilities during the relief phase are defined by each society's charter and policies, but generally they are concerned with providing shelter, food, and clothing and with supplementing the medical and nursing care services of the government. In areas where the medical and public health services are not sufficiently developed, the entire responsibility for providing medical care and preventive services during relief operations may fall on the Red Cross, which may even be involved in the provision of all means and services connected with shelter, e.g., water supply, wastes disposal, and vermin control. There are many areas in which close co-operation should be established between the environmental health services and the Red Cross. The main areas are:

(1) sanitation in temporary shelters and camps;

(2) food sanitation in mass feeding centres;

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<sup>1</sup> The term "Red Cross Society" as used here also covers the Red Crescent and the Red Lion and Sun societies.

- (3) sanitation in medical care centres (first-aid stations and hospitals);
- (4) water supply;
- (5) wastes disposal;
- (6) control of vermin;
- (7) disinfection, disinfestation, laundering and bathing centres.

It is strongly recommended that the environmental health services and the national Red Cross Society collaborate in the pre-disaster planning of emergency sanitation measures. The Red Cross Society, in accordance with its policies, may find it within its responsibility to stockpile supplies and equipment needed for relief sanitation.

### **Civil defence organization**

In certain countries the civil defence organization is in complete charge of relief operations. In others, it is involved at least in warning, evacuation, search and rescue activities. These activities take place immediately before or after the disaster strikes. Since sanitation personnel become involved in these activities, they should co-operate closely with the civil defence officials. Early knowledge of the catastrophe, as the result of contact with the civil defence office, means earlier mobilization, and this is a very important element in emergencies.

### **Government forces**

#### *1. Armed forces*

Modern armies are well-equipped and mechanized. They can be very helpful in relief operations because they have well-disciplined and trained men, good field vehicles, heavy earth-moving machines, tank trucks, mobile water purifiers, and many other items of equipment and supplies that are useful in sanitation work. The air force can provide helicopters and planes for rescue and for the quick transport of men and supplies. The navy can be very helpful to coastal communities in disasters. All these possibilities should be explored and used to the best advantage. Here again, the initiative of the director of the environmental health programme plays an important role in making good use of such opportunities.

#### *2. Police force*

The main tasks of the police are to preserve peace, maintain order, and protect property. The maintenance of order is often difficult when the public is panic-stricken, but is essential to every relief activity, including sanitation. The protection of water sources or water distribution facilities

may become necessary, and the assistance of the police may be required for enforced evacuation or compulsory disinfestation. To ensure their prompt intervention on such occasions, close contact with the police should be maintained. If insufficient policemen are available, the armed forces may be called in to restore order.

### **Other governmental or municipal services**

#### *1. Fire brigades*

Fire brigade personnel are well trained in search and rescue, fire-fighting, inspection of buildings for safety, and accident prevention. A fire brigade is normally equipped with good tank trucks which may be disinfected and used for distribution of water.

#### *2. Public works department*

Public works departments have heavy equipment, tank trucks, mobile pumps, and power units suitable for use in emergency sanitation. They also have trained engineers and technicians who may be deployed for the provision of water and sewage disposal services. If the water and sewage works are operated by the public works department, there is still more reason for the environmental health service to strengthen working relations with this department.

#### *3. Communications*

The importance of efficient communications at the time of an emergency is beyond question. Messages and instructions to the field staff, as well as progress reports and requests for supplies to the relief headquarters, need to be transmitted promptly. Radio and telephone communications facilitate the work, reduce the number of field visits, and save time. If communications in the area are not properly developed, use should be made of army field equipment. The environmental health staff should make the best use of the available means of communication.

### **Voluntary societies**

Societies, clubs, and other groups who volunteer to assist in emergencies provide a good source of auxiliary manpower. In normal times, orientation and training courses for the members of voluntary groups should be arranged. A minimum programme might consist of a series of conferences and demonstrations; informative pamphlets that avoid unnecessary technical details would be useful to voluntary groups. In the field, volunteers

should be assigned to well-defined simple tasks under the supervision of professional sanitation workers. Voluntary societies may also contribute funds for the purchase of small items.

### **Bilateral and multilateral agencies**

Bilateral agencies (such as the US Agency for International Development) and multilateral organizations (e.g., regional development pacts) have resources in manpower, equipment, supplies and funds that may be available for the relief of the afflicted population. These possibilities should not be overlooked and the environmental health service should co-ordinate the sanitation work of these agencies.

## Annex 3

### ASSISTANCE OF INTERNATIONAL AGENCIES

#### League of Red Cross Societies

The following quotations from the *International Disaster Relief Manual*<sup>1</sup> define the functions of the League of Red Cross Societies in natural disasters:

The League of Red Cross Societies founded on May 5, 1919, is the international federation of National Red Cross Societies, an association of unlimited duration having the legal status of a corporate body . . .

The general objectives of the League are to encourage and facilitate at all times the humanitarian activities of the National Societies and to assume the responsibilities laid on it as a federation of these Societies . . .

Under certain conditions and with the consent of the National Society involved, the League Secretariat [may] act in the capacity of an operating agency as well as a coordinating agency . . .

Red Cross emergency relief is intended to meet the physical needs of disaster-affected individuals and families. The extent of these needs is determined by the nature of and the environmental conditions created by the disaster. Emergency relief may include feeding, lodging, clothing, medical and nursing care, and registration and information services. It may also include such services as counselling; vocational and leisure-time activities; locating and reuniting families.

In addition to physical needs, disaster-affected individuals will experience some degree of emotional tension. In planning emergency relief services, this factor must be taken into consideration because the emotional needs of people may be as important as their physical needs.

On the basis of these statements and the policies of the League as laid down in the *Manual*, the League provides assistance in major disasters when this is requested by the national Red Cross Society. The League's policy on donations is limited to articles of direct human need, but certain sanitation supplies such as water disinfectants and pesticides are provided upon the request of the chief of medical services.

Section C, Chapter 4 of the *Manual*, entitled "Mass care centres", deals with numerous environmental health matters such as space requirements, heating and lighting, insect and rodent control, fire protection and safety practices, water supply, washing, bathing and laundry installations, disposal

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<sup>1</sup> League of Red Cross Societies (1959) *International disaster relief manual*, Geneva.

of human wastes and refuse, and the organization of tent camps. Section B, Chapter 5 recommends the recruitment of a "sanitary officer" whose duties are described as follows:

The sanitary officer reports to the chief of medical services and assists mass care centre personnel in carrying out:

- (1) Inspection of kitchens, washrooms, latrines and other facilities.
- (2) Disinfection of living quarters, latrines, washrooms, swimming pools, garbage pits and bins, and drainage system.
- (3) Examination of drinking-water and measures for its purification if indicated.
- (4) *Organizing and building a de-lousing station.*
- (5) Liaison with the local authorities who, under normal conditions, have supervision of the water supply and public sanitation.
- (6) Conduct of anti-fly and vector control campaigns.

The importance attached by the League of Red Cross Societies to environmental health measures is clearly shown in the policies and procedures contained in the *Manual*. Environmental health officers in every country should know about the assistance that the League can provide, maintain contact with the national Red Cross, and establish lines of communication and co-operation so that, when required, the assistance of the League can be obtained without undue delay.

The Twentieth International Conference of the Red Cross, held in Vienna in October 1965, underlined the importance of planning relief work in order to cope with disasters, and unanimously approved a resolution requesting the Secretariat of the League of Red Cross Societies to continue to encourage and assist national Red Cross/Red Crescent Societies in their organization and preparedness for relief actions.

The General Assembly of the United Nations, at its twenty-third session in December 1968, adopted a resolution inviting governments which have not already done so to make national preparations to meet natural disasters and urging the Secretary-General, in co-operation with the League of Red Cross Societies and other international organizations concerned, to consider ways of expanding assistance to governments in this field.

The League of Red Cross Societies has recently published a *Disaster relief handbook*,<sup>1</sup> which provides advice on the planning and the actual implementation of relief and outlines plans for training different types of relief personnel. It contains a "Guide to a natural disaster relief plan", so presented as to serve as a check-list for items to be included when drafting a national plan. The *Handbook* is in loose-leaf form so that it can readily be revised in the light of new developments. The League intends to send groups of experts to various countries to stimulate

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<sup>1</sup> League of Red Cross Societies (1970) *Red Cross disaster relief handbook*, Geneva.

and help governments and national Red Cross Societies to prepare relief plans. The League is also promoting training programmes for special relief personnel to serve outside their own countries, and is organizing a leadership course.

### **The United Nations and its specialized agencies<sup>1</sup>**

#### *United Nations*

The United Nations has received many appeals for assistance from developing countries stricken by natural disasters. As a result of these appeals the Economic and Social Council, at its thirty-sixth session in 1963, requested the Secretary-General to take the lead in establishing, in conjunction with the specialized agencies and the League of Red Cross Societies, appropriate arrangements for assistance in rapid and concerted relief and reconstruction in the event of natural disasters, and to study the types of assistance which it might be appropriate for the United Nations to provide, the order of magnitude of the resources that the Secretary-General might require for this purpose, and the alternative methods of providing such resources.

The Secretary-General reported to the General Assembly at its nineteenth session in 1965 the action taken by the United Nations and its specialized agencies; he recommended that United Nations assistance should concentrate on sending experts with special technical skill quickly to the scene of a disaster, providing special equipment for rescue, and drawing up comprehensive disaster relief plans in collaboration with each government. He received authorization to draw from the Working Capital Fund a total of \$100 000 for emergency aid in any year, with a normal ceiling of \$20 000 per country in the case of any one disaster. He also listed the main fields in which United Nations advisory assistance would be most needed for carrying out long-range programmes of rehabilitation and reconstruction.

In 1968 the General Assembly reiterated the importance of pre-disaster planning as a means of mitigating the effects of natural disasters and recognized the importance of scientific research and modern technology in reducing the impact of natural disasters on man and society. In 1969 the

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<sup>1</sup> The information in this and the following sections is taken from the documents listed below:

1. United Nations, General Assembly (1965) *Assistance in cases of natural disaster : report of the Secretary-General*, New York (mimeographed document A/5845);
2. United Nations, Secretariat of the Administrative Committee on Co-ordination (1966) *International action in cases of natural disaster : a manual on the resources and procedures of the United Nations family*, New York (mimeographed document); and
3. United Nations, Economic and Social Council (1970) *Assistance in cases of natural disaster : interim report of the Secretary-General* (mimeographed document E/4853).

General Assembly adopted a resolution increasing the amount the Secretary-General may draw for emergency aid in connexion with natural disasters to \$150 000 in any year, with a normal ceiling of \$15 000 per country in the case of any one disaster, on the understanding that the Secretary-General has the authority to grant a maximum of \$20 000 at his discretion. The General Assembly also authorized the Secretary-General to advance, from the balance remaining in any one year, amounts not exceeding \$10 000 per country for assistance to governments, at their request, in the elaboration of plans to meet natural disasters.

#### *United Nations Development Programme (UNDP)*

The United Nations Development Programme, through its regular technical assistance programme, helps governments in various ways to anticipate and offset the worst effects of disasters through projects on earthquake engineering and seismology, building construction and rehabilitation, river regulation and control, meteorological and hydrological services, weather warning, flood and typhoon forecasting and warning systems, research on locust migration and control, etc.

Although precise machinery for providing immediate assistance at the time of disaster has not yet been established, 30 projects relating to natural disasters and with a total budget of more than \$30 000 000 were approved between December 1959 and January 1970. About half of these projects have been completed.

The UNDP Resident Representative in each country receives government requests and normally acts as co-ordinator of the emergency work of the United Nations system.

#### *Office of the United Nations High Commissioner for Refugees*

The United Nations High Commissioner for Refugees has at his disposal an emergency fund for refugee relief of up to \$500 000. This fund is destined for expenditures in emergencies that result from sudden waves of refugees rather than from natural disasters. Nevertheless, it is possible—as happened in Agadir and Skopje—for refugees to become victims of a natural disaster. On such occasions the High Commissioner has been able to make an allocation from the emergency fund for relief to refugees living in an area within his competence and affected by a natural disaster.

#### *World Health Organization*

A major part of the regular work programme of WHO consists of providing advice and technical assistance in areas such as communicable diseases control, environmental sanitation, and other health fields that are closely linked to the capacity of public health administrations to meet emergency situations.



The Constitution of WHO specifies that one of its functions is to furnish necessary aid in emergencies upon the request or acceptance of Governments (Article 2), and prescribes the establishment of a special fund to meet emergencies and unforeseen contingencies (Article 58). In fulfilling these obligations, WHO has often provided direct assistance in emergencies caused by natural disasters and has collaborated with other organizations of the United Nations system, the International Committee of the Red Cross and, in particular, the League of Red Cross Societies.

In 1954 the Seventh World Health Assembly decided to establish an "Executive Board Special Fund" of \$100 000 to be used at the discretion of the Board for emergencies and unforeseen contingencies; amounts so used are replaced by a specific provision in the budget of the following year.

To enable urgently needed materials and equipment for emergency health relief to be obtained without delay, WHO operates a special purchase service for governments. No charge is made for this service. During 1969 WHO responded to requests for assistance in natural disasters as follows:

Algeria (floods): services of WHO field staff; malaria control team.

Guatemala (hurricane): medical supplies; water disinfectants.

Iraq (floods): malaria control advice.

Pakistan (tornadoes): medical supplies.

Syria (floods): medical supplies; epidemiologist; environmental health advice; services of WHO field staff.

Somalia (drought): services of WHO field staff.

Tunisia (floods): medical supplies; epidemiological team; sanitary engineering advice.

Yugoslavia (earthquake): epidemiological and sanitary engineering advice.

WHO may offer emergency assistance to a government without awaiting a specific request when it is clear that such assistance would materially improve the available physical or organizational resources, or when the situation threatens the public health of neighbouring countries.

WHO, with the collaboration of the League of Red Cross Societies, has assumed responsibility for co-ordinating the health relief services provided by official and voluntary agencies in numerous major emergencies.

#### *United Nations Children's Fund (UNICEF)*

UNICEF is concerned primarily with long-range programmes of assistance to mothers and children in developing countries; this assistance, however, is extended to emergency aid when no other sources are immediately available. Milk, vitamin capsules, drugs and vaccines are among the supplies UNICEF normally provides in the immediate post-disaster period; on certain occasions rice, blankets, clothing and vehicles have also been supplied. To expedite the delivery of these supplies, the Executive Board reviewed criteria for emergency aid in 1965 and established the

principle that supplies and vehicles on hand in the afflicted country could be diverted for relief purposes and that the reserve stocks in the main UNICEF Packing and Assembly Centre in the free port of Copenhagen could also be called upon. Furthermore, the Executive Director has at his disposal an emergency aid reserve fund of \$100 000, and may call on a further \$100 000 in special circumstances.

When UNICEF is asked for long-term aid after disasters, preference is given to the restoration of permanent services for mothers and children. The restoration or replacement of equipment and supplies provided under earlier UNICEF-assisted projects receives top priority. Besides providing equipment and supplies not usually available in the country for the restoration of public health, school and other community services, UNICEF may in exceptional cases make limited cash grants for specific purposes.

From 1965 to 1969 UNICEF assistance in natural disasters in Colombia, India, Iraq, Italy, Southern Yemen, Syria and Yugoslavia amounted to about \$2 750 000.

#### *Food and Agriculture Organization of the United Nations (FAO)*

FAO provides emergency aid to meet food shortages and to assist in the rehabilitation of agriculture in areas stricken by sudden calamities such as earthquakes, floods, and invasions of locusts.

Food aid is given under the World Food Programme emergency allocation. Although resources are not specifically earmarked for technical assistance in disasters, in special situations FAO makes specialists available to advise on protective measures against animal diseases, repairs to irrigation systems, land settlement, timber requirements in rebuilding houses, and so forth. Long-term rehabilitation measures are covered by normal programmes separate from emergency relief.

FAO recognizes the importance of pre-planning for disaster and lays particular stress on advance preparations. A booklet on *Food and nutrition procedures in times of disaster* was distributed to governments and field officials in 1967; it refers, among other things, to the need for a standing committee responsible for precautionary measures and relief organization. FAO also gathers monthly information on crop conditions and the general food situation from all over the world as part of a systematic effort to keep constantly under surveillance any serious food shortages that may be developing and to provide early warning for remedial or relief action.

#### *World Food Programme*

The administration of the World Food Programme is the joint responsibility of the United Nations and FAO. Of all the organizations of the United Nations system, the World Food Programme has the largest financial resources for disaster relief. Emergency aid is given mainly in

the form of food, for populations afflicted not only by sudden natural disasters but also by man-made crises and food scarcities caused by droughts, pests and diseases.

From 1962 to 1969, food assistance worth about \$62 200 000 was given to victims of natural disasters. When the Programme was first established, expenditure of \$7 000 000 per year was authorized for emergency aid; in 1966 the figure rose to \$15 000 000 and in 1969 to \$20 000 000. The increase is attributed partly to the serious crises of the year 1969, and partly to the fact that governments are becoming increasingly aware of the availability of assistance.

Disaster assistance is not limited to the immediate relief of suffering but is almost invariably followed by rehabilitation or reconstruction projects. Stockpiling of emergency food is not undertaken by the Programme, but stocks destined for economic and social development projects may on occasion be temporarily diverted for emergency use. Food aid provided under the regular programme of the World Food Programme is directed at projects of irrigation development, flood control and watershed management to help forestall or minimize the impact of floods, cyclones, drought, and similar disasters.

*United Nations Educational, Scientific and Cultural Organization  
(UNESCO)*

The main contribution of UNESCO to emergency aid in natural disasters is concerned with scientific studies of earthquakes and volcanic eruptions; this work includes the collection and analysis of data and the training of scientists. UNESCO has arranged with the main seismological data centres, the International Association of Volcanology, and other institutions to receive immediate notice of the occurrence of an earthquake or volcanic eruption so that a mission can be sent promptly to investigate the causes and effects, advise on measures for the protection of the population, etc.

Since 1962 UNESCO has sent major missions to study in detail the effect of earthquakes in ten places; these missions proved so successful that in 1968 it was decided to extend the scientific missions to examine the impact of windstorms. UNESCO co-operates closely with national and international non-governmental institutions in the study of earthquakes, volcanic eruptions, cyclonic storms and floods, and in the development and use of warning systems and appropriate protective measures.

In 1968 UNESCO assumed responsibility for certain activities of the International Relief Union and undertook to continue the work of the Union in the scientific study of natural disasters and means of protection against their effects. UNESCO also agreed to continue the publication of a review of the scientific aspects of disaster prevention in the form of an annual summary of information and data.

### *Other organizations of the United Nations system*

The *International Labour Organisation* does not provide emergency relief, although it maintains a list of experts ready to advise on rescue operations during mine disasters and on precautionary measures. The Organization is mainly concerned with the long-term needs arising from natural disasters; its main contribution is in the field of vocational training during the reconstruction and rehabilitation stages. ILO also provides experts for advisory service and training and for certain types of demonstration equipment.

The *World Meteorological Organization* is concerned with the meteorological aspects of disaster detection and warning systems, and plays an important role in the international co-ordination of activities in this field. Together with the Economic Commission for Asia and the Far East, WMO has been actively engaged in establishing the Intergovernmental Typhoon Committee in South-East Asia and is exploring the possibility of setting up similar committees elsewhere.

The *International Civil Aviation Organization* provides temporary assistance at short notice, including experts to supervise and operate ground services at airports. ICAO can also provide equipment for re-establishing aeronautical services in certain cases and areas, but less rapidly.

The *International Monetary Fund* assists its members during natural disasters in accordance with the Articles of Agreement and its established procedures and policies. The FUND's resources can be allocated at short notice to meet expenditure occasioned by a natural disaster. The FUND may also send out members of its staff to assist in matters within its competence.

The *International Telecommunication Union* has made arrangements for giving priority in the international telecommunications system to messages on which human lives may depend.

### **Other intergovernmental organizations**

The *Council for Mutual Economic Assistance* is concerned with flood prevention and control; it has collaborated in establishing arrangements between neighbouring countries for joint precautionary and relief action in frontier zones exposed to flooding. The Council has also drawn up regulations for the design and planning of structures and buildings in seismic areas.

The *Organization of American States* established in 1968 an Inter-American Emergency Aid Fund to supply food, medical equipment and medicines, or other types of material, technical and financial assistance to any member that is threatened by, has suffered from, or is in an emergency situation whatever its origin. An Inter-American Emergency Aid Committee is in charge of concluding agreements for the efficient and rapid

mobilization of available goods, services and resources; the Committee is also responsible for giving the technical assistance necessary for the preparation of national pre-emergency plans.

### **Non-governmental organizations**

The *International Committee of the Red Cross* is primarily concerned with armed conflicts and internal disturbances that require the intervention of a specifically neutral Red Cross body. By mutual agreement between the International Committee of the Red Cross and the League of Red Cross Societies, the latter is responsible for emergency situations arising from natural disasters.

The *International Civil Defence Organization* is concerned with the problems of mobilization and evacuation. It maintains close liaison with national civil defence bodies, facilitates exchange of information and experience, and co-ordinates efforts to establish and develop civil defence. The organization also carries out studies on methods of evacuating civilians and on the constitution of safety zones, and research on civil defence problems.

Other non-governmental international organizations engaged in promoting, organizing and sponsoring relief work include the International Relief Union, the International Life-Saving Federation, the International Association for Life-Saving and First Aid to the Injured, the International Commission for Alpine Rescue and the International Life-Boat Conference.

### **Governmental relief units**

Several governments have established stand-by relief units for giving emergency assistance abroad upon the request of the government of the afflicted country or the United Nations; matters pertaining to the legal status of these units and procedures for using and co-ordinating their services are still being studied by the United Nations. Thus the Government of Norway has set up a Surgical Disaster Unit and a Field Hygiene Team that can be made operative at short notice, and the Swedish Stand-by Force for United Nations Service, a technical unit trained and equipped for use in peace-keeping operations, can also be deployed for assistance in natural disasters. Other governments having similar units include Austria, Belgium, Czechoslovakia, Finland, France and Italy.

Most governments of developed countries have appropriate means and machinery for providing other countries with emergency aid in natural disasters; they help directly or through the national Red Cross body and the League of Red Cross Societies.

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## Annex 4

### STOCKPILE OF EQUIPMENT AND SUPPLIES

The amount of equipment and supplies to be stored for use in disasters depends on such factors as the types of disaster that might occur and the likelihood that they will occur, the number of people and size of the area likely to be involved, the road and communication systems, the commercial availability of the materials and supplies needed, the financial resources of the relief body or government departments concerned, and purchasing procedures and regulations. It is therefore not possible to give a definite list of the supplies and equipment required.

Nevertheless, a tentative list of sanitation equipment and supplies required to satisfy the needs of 10 000 people is given below for guidance. In certain countries or localities, additional items may be needed and others may be deemed unnecessary. The relief body and governmental departments concerned with relief work in each country should make a rational appraisal of their needs. The equipment and supplies may be either stockpiled in one place or distributed to several regions with adequate provision for their immediate transfer from one region to another in the event of disaster.

<i>Item</i>	<i>Quantity</i>
<b>Water supply</b>	
Mobile chlorinator, mounted on truck or trailer, with 2 liquid chlorine cylinders	1
Mobile hypochlorinator, mounted on truck or trailer, with solution tanks, hose and accessories	5
Mobile water purification unit, capacity 200-250 litres/min	4
Mobile workshop or repair unit: including repair and pipelaying tools, fittings, jointing materials, excavation tools, winch, pipe wrenches, valves, hose, welding equipment and materials, boots, working gloves, goggles, etc.	1
Tank trucks for water, capacity 7 m <sup>3</sup>	10
Water distribution tanks, capacity 0.2-10 m <sup>3</sup>	100-200
Portable elevated storage tanks with supporting elements and accessories, easy to assemble, capacity 10-20 m <sup>3</sup>	5-10
Well-driving equipment and well points	2 sets
Hand-operated pumps for water, capacity 15-20 litres/min	100
Electric or engine-driven pumps, capacity 200-250 litres/min	4

<i>Item</i>	<i>Quantity</i>
Pipes (cast iron, galvanized, asbestos cement), diameter 1.25–10 cm, with valves and fittings	<i>a</i>
Chlorinated lime (25–30%), stored in a cool and dry place and renewed every 6 months	10–20 tons
Calcium hypochlorite (60–70%), in powder or granule form, stored in a cool and dry place and renewed every 2 years	5–10 tons
Chlorine or iodine-liberating tablets	100 000
Alum, ferric chloride, and other chemicals for water treatment	2–5 tons
Masonry tools, complete	2–5 sets
Carpentry tools, complete	2–5 sets
Truck-mounted generators	2
Collapsible tanks (assorted) with total capacity of	100–500 m <sup>3</sup>
 <b>Waste water, sewage and excreta disposal</b>	
Mobile mud pump	2–5
Sludge pump (non-clogging diaphragm or other type)	2–5
Sludge tank trucks, capacity 7 m <sup>3</sup>	5
Augers (earth-type)	5–10 sets
Mobile repair shop with necessary tools and equipment, masks, boots, working gloves, excavation tools, etc.	1 unit
Pipes (cast iron, asbestos cement, concrete), with joining materials and equipment, diameter 10–30 cm	<i>a</i>
Moulds (iron or wood) for concrete pipes and slabs	10–20 sets
Cresol-base disinfection materials (e.g., creolin)	50–100 barrels
Timber, board, nails, etc.	
 <b>Vermin control</b>	
Power sprayers	2
Hand-pressured sprayers, capacity 20–30 litres	50
Dusters (hand-operated, plunger type)	50
Dusters, power-operated	2
Space sprayer	1
Adequate supply of accessories and spare parts for the above equipment	
Insecticides:	
DDT, technical powder	0.5 tons
DDT, 75% water wettable	1–2 tons
DDT, 10% powder	1 ton
dieldrin, 0.625–1.25% emulsifiable concentrate or wettable powder	100 kg
lindane, 0.5% emulsifiable concentrate or wettable powder	100 kg
chlordane, 2% emulsifiable concentrate or wettable powder	100 kg
malathion, 1% emulsifiable concentrate or wettable powder	100 kg
dichlorvos emulsion	100 litres
Rodenticides, anticoagulant type (warfarin, etc.)	1–2 kg
Rodent traps	100
Screen, for fly control	10 rolls
Garbage cans, capacity 50–100 litres	300–500
Shower trucks (for bathing)	2

*a* Quantity depends on availability and on distribution within the country.

## Annex 5

### THE SANITARIAN'S EQUIPMENT

<b>Work equipment</b>	<i>Item</i>	<i>Quantity</i>
Comparator for chlorine residual and pH, together with orthotolidine and pH indicator solutions		1
Thermometer, 0–100° C, with protective casing		1
Tape measure, cloth or metal, 30 m, graduated in m and cm		1
Tape measure, metal, pocket size, 2 m		1
Standard household measuring cup, 500 ml		1
Clip board		1
Flashlight (pocket type) with spare batteries and bulbs		1
Magnifying glass (pocket type), 5x to 20x		1
Collection vials		1 dozen
Felt-tip ink marking pen		1
Pocket compass, with plastic case		1
Plumb rod		1
Spirit level		1
Mosquito larvae dipper		1
Aspirator with stoppered tubes, for collecting mosquitos		1
Kit for membrane filter for water testing (complete)		1
Water pressure gauge, positive and negative pressure		1
Hand level		1
Rapid phosphatase determination kit		1
Drawing board and instruments		As required

### **Sleeping and cooking equipment for a field team of 5 sanitarians**

Tent(s)		
Blankets		10
Camp beds		5
Bed sheets		10
Sleeping bags		5
Pillows with spare covers		5
Kerosene heater		1
Kerosene or gas stove		1
Kerosene lamp		1
Kerosene lantern		1
Water filter (household type)		1
Flashlights (with spare batteries)		5
Rubber boots		5 pairs
Thermos flasks		2
Felt-covered water bottles		5
Cooking utensils (assorted)		1 set



<i>Item</i>	<i>Quantity</i>
Eating utensils (assorted)	1 set
Packaged daily rations (non-perishable)	50
Detergents, soap, water disinfecting tablets, etc.	As required
Portable shower unit	1
Water containers (plastic or metal), capacity 10-20 litres	2
Kerosene containers (plastic or metal), capacity 10-20 litres	2
Camp chairs	6
Camp tables	2

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## Annex 6

### SUMMARY OF SANITATION REQUIREMENTS IN DISASTERS

The main recommendations and standards given in this Guide are summarized below, for easy reference.

#### **During evacuation**

##### *Water*

Minimum 3 litres (0.8 US gal) per person per day in cold and temperate climates.  
Minimum 6 litres (1 ½ US gal) per person per day in hot climates.  
Water from suspected sources must be boiled or disinfected.

##### *Waste disposal*

All-purpose trench: depth 60 cm (2 ft); width 45 cm (1 ft 6 in); length 3 m (10 ft) per 1000 persons.

##### *Food*

Non-perishable, not requiring cooking.

#### **During relief operations**

##### *Tent camps*

###### *Site :*

slope of land and nature of soil favouring easy drainage;  
protected from adverse weather conditions;  
away from mosquito breeding-places and refuse dumps;  
away from commercial and industrial zones.

###### *Layout :*

area 3-4 hectares per 1000 persons (330-440 ft<sup>2</sup> per person);  
width of roads 10 m (33 ft);  
minimum distance between tent pegs and edge of road 2 m (7 ft);  
minimum distance between tents 8 m (26 ft);  
minimum floor area in tent 3 m<sup>2</sup> (33 ft<sup>2</sup>) per person.

###### *Water distribution :*

minimum capacity of tanks 200 litres (50 US gal);  
maximum distance from farthest tent 100 m (330 ft).

###### *Refuse containers :*

metallic with tight lid;  
capacity 50-100 litres (13-26 US gal);  
1 for every 4-8 tents or 25-50 persons.

*Latrine accommodation :*

5-6 seats per 100 persons;  
distance from tents 30-50 m (100-160 ft).

*Washing :*

ablution bench, double-sided, 3 m (10 ft) long;  
2 for every 100 persons.

*Buildings**Accommodation :*

minimum floor area 3.5 m<sup>2</sup> (40 ft<sup>2</sup>) per person;  
minimum air space 10 m<sup>3</sup> (350 ft<sup>3</sup>) per person;  
minimum air circulation 30 m<sup>3</sup> (1100 ft<sup>3</sup>) per person per hour;  
minimum distance between beds 75 cm (2 ft 6 in).

*Washing :*

1 hand basin for every 10 persons, or 1 wash bench, 4-5 m (13-17 ft) in length,  
for every 100 persons;  
1 shower head for 50 persons in temperate climates, 1 for every 30 persons in hot  
climates;  
separate blocks for men and women.

*Toilet accommodation :*

1 seat for every 25 women, 1 seat and 1 urinal for every 35 men;  
maximum distance from building 50 m (160 ft).

*Refuse containers :*

capacity 50-100 litres (13-26 US gal), 1 for every 12-25 persons.

*Water supply**Daily consumption :*

field hospitals 40-60 litres (10-15 US gal) per person;  
mass feeding centres 20-30 litres (5-8 US gal) per person;  
temporary shelters and camps 15-20 litres (4-5 US gal) per person;  
washing installations 35 litres (10 US gal) per person.

*Water disinfection :*

routine residual chlorine 0.7-10 mg/litre;  
disinfection of pipes: 50 mg available chlorine per litre for 24 hours' contact, or  
100 mg available chlorine per litre for 1 hour's contact;  
disinfection of wells and springs: 50-100 mg per litre for 12 hours.

*Water protection :*

distance between water source and source of pollution 30 m (100 ft).

*Protection of wells :*

impervious casing 30 cm (1 ft) above and 3 m (10 ft) below ground surface;  
radius of concrete platform around well 1 m (3 ft 3 in);  
radius of fenced area 50 m (160 ft);  
bottom of cesspools and latrines 1.5-3 m (5-10 ft) above water table.

*Water storage :*

capacity sufficient for 1/2-1 day on the basis of the mean daily consumption.

*Water quality :*

total dissolved solids: less than 1500 mg/litre;  
 chlorides: less than 600 mg/litre;  
 coliform organisms: MPN<sup>1</sup> 1–10.

*Latrines**Shallow trench latrine :*

width 30 cm (1 ft) or as narrow as it can be dug;  
 depth 90–150 cm (3–5 ft);  
 length 3.0–3.5 m (10–12 ft) per 100 persons.

*Deep trench latrine :*

width 75–90 cm (2 ft 6 in–3 ft);  
 depth 1.8–2.4 m (6–8 ft);  
 length 3–3.5 m (10–12 ft) per 100 persons.

*Bore hole latrine :*

diameter 40 cm (16 in);  
 depth 5–6 m (16–20 ft);  
 1 for every 20 persons.

*Refuse disposal**Trench :*

width 1.5 m (5 ft);  
 depth 2 m (7 ft);  
 length 1 m (3 ft 3 in) per 200 persons, so that the trench is filled in one week;  
 depth of compact earth cover 40 cm (16 in);  
 time allowed for decomposition 4–6 months.

*Food sanitation**Disinfection of eating utensils :*

boiling water for 5 minutes;  
*or* : chlorine solution, 100 mg/litre for 30 seconds;  
*or* : quarternary ammonium compounds, 200 mg/litre for 2 minutes.

*Vector control**Insecticide spraying :*

see tables in Annex 9.

*DDT dusting, 10 % :*

30 g (1 oz) per person.

*Sanitation personnel required*

See Table 1, page 29.

<sup>1</sup> Most probable number per 100 ml of water.

## Annex 7

### URBAN WATER SUPPLY QUESTIONNAIRE FOR WATERWORKS SUPERINTENDENTS \*

All the questions in the following list can be answered with a simple "Yes" or "No". The questionnaire is designed to help waterworks superintendents assess how well prepared their plant is to meet emergencies, and to be used as a guide to improve preparedness. It may be retained for future reference as an aid in programme planning and recording accomplishments.

#### **General**

Does your plan provide for alternative situations such as:

- (1) The community is within or on the fringe of an area in which some destruction can be expected?
- (2) The community is a potential reception area for evacuees?

Does your community health agency have a role in emergency water planning?

Has planning taken into consideration the relationship and interdependence of the various utilities—water, electricity, gas, transportation, etc.?

Is there close liaison with other utilities?

#### **Basic inventory of water resources**

Has an inventory of all water resources been made?

Does the inventory include:

- (1) ground and surface water?
- (2) public and private ponds, reservoirs, swimming pools, and water available through interconnections?

Do the data show (a) the quantity, (b) the quality, and (c) the location of water resources?

Does the inventory include water which is a reasonable distance beyond the boundaries of the community?

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\* Based on a questionnaire issued by the US Public Health Service.

## Facilities

Have bottlenecks to improving quantity production under emergency conditions been:

- (1) identified?
- (2) planned and scheduled for elimination?

Has the continuous maximum production capacity of the water treatment facility been determined?

## Protection

Have precautionary measures been taken to safeguard the facilities and resources from panic-stricken mobs by:

- (1) planning for monitoring water supplies, treatment installations, and equipment against acts of vandalism?
- (2) developing plans and procedures for physical protection of facilities and resources in an emergency?
- (3) providing night lighting and fencing?

## Communication

In the event of disaster, will there be available a communications system, such as radio or mobile telephone, for maintaining contact between:

- (1) community utilities (water, gas, electricity, etc.)?
- (2) operating, maintenance and repair crews?

Will there be a warning system to notify the public about water usage, contamination, etc.?

Has the public been alerted to conditions that might arise in an emergency pertaining to water supplies?

## Emergency priority for water use

Is there a list assigning an order of priority to essential water users? (Hospitals should have first priority.)

Does your local government or local water agency have emergency authority to forbid use of water for non-essential purposes such as washing cars, watering grass?

Is your water distribution system equipped with cutoffs to enforce water priorities?

Have alternative sources of water supply for industrial and fire-fighting uses been identified? (Examples: well water or nonpotable water.)

### **Repairs, rebuilding and construction**

Has authority been assigned to a community government agency to carry out major repairs, rebuilding, or new construction ?

Does the construction agency have available heavy equipment such as bulldozers, tractors, earthmovers, concrete mixers ?

Have sources of supply been identified for construction, repair and replacement materials such as cement, sand, steel, electric wire, pipes, valves, fittings, etc. ?

Has thought been given to financing emergency water activities ?

### **Basic documents**

Are there available:

- (1) city maps of practical scale with pertinent points marked ?
- (2) engineering drawings of water treatment, distribution and storage facilities, and of inter-connections with industrial and other water supplies ?
- (3) detailed drawings of the distribution system, with pipe sizes, fittings, couplings, valve locations ?
- (4) survey notes ?
- (5) current written operating procedures ?
- (6) emergency procedures based on the various assumptions ?
- (7) mutual aid agreements ?
- (8) lists of readily available suppliers of essential chemicals ?
- (9) lists of trained personnel and their emergency assignments ?
- (10) copies of the emergency water plan ?
- (11) copies of these documents at a site safe in an emergency ?
- (12) current list, by name, home address, and telephone number, of key personnel and alternates who are familiar with the nature and location of these basic documents and have access to them ?

### **Personnel**

Are trained auxiliary personnel available to the water authorities ?

Have the personnel been trained in chemical, biological and radiological detection and corrective operating procedures ?

Is a sanitary engineer on the staff or available ?

Is there a recognition or identification system for water utilities personnel to pass through police and fire lines ?

Are emergency operations exercises conducted periodically ?

Are personnel (regular and auxiliary) trained in emergency water procurement, treatment and distribution techniques ?

Is there a continuing programme for training supervisory and operating personnel in emergency management and operation?

Is the training programme designed to provide personnel with on-the-job experience?

Have provisions been made for protection and emergency medical care of operating personnel under dangerous conditions?

### **Transportation**

Are there in your community vehicles that could be used to transport potable water?

Have arrangements been made to make these available for emergency water transportation?

Are there plans for a system of central water distribution, i.e., fire hydrant or similar facility?

If not, has consideration been given to such a distribution system?

Do plans provide for the use of local dairies and other bottling facilities to bottle and transport water?

### **Reserve supply and standby equipment**

Is your reserve stock of chemicals and spare parts sufficient for a 30-day emergency?

Is there a preventive maintenance programme in effect?

Is standby equipment tested periodically?

Is there available an inventory of your community's reserve mobile equipment, such as chlorinators and pumps, that can be moved quickly to emergency sites?

### **Power**

Is a substitute source of power available if the prime source is made ineffective?

Are standby generators and pumps available?

Is there an accessible fuel reserve such as liquid fuel for operation of auxiliary power facilities in case of power failure?

To the extent practicable, has power generating equipment been provided with protection from hazards?



**Laboratory**

Have arrangements been made to expand present laboratory facilities to provide emergency quality control of water, including chemical, biological and radiological detection?

Have regular and auxiliary personnel been trained to detect chemical, biological, or radiological pollutants in water?

**Public information**

Are water users informed of the measures to be taken (*a*) by the community water authority and (*b*) by themselves if the water service fails as the result of a disaster?

**Mutual aid and assistance**

Do agreements provide for assistance in:

- (1) water resources?
- (2) personnel?
- (3) materials and equipment?
- (4) scarce supplies such as chemicals?

Have plans been made for exchange of personnel for on-the-job training in the various water systems and operating facilities?

Is there close contact in community water planning between the parties to the assistance agreements?

## Annex 8

### DISINFECTION OF WATER MAINS \*

When a section of a water main is laid or repaired it is impossible to avoid contaminating the inner surface with the dirt, mud or water in the trench while the pipes are being fixed into place. Contamination may also occur by accident, negligence or malice; adequate surveillance during non-working hours and the plugging of open ends after the day's work will reduce these risks. It should be assumed, however, that the pipe is contaminated despite all the precautions taken to prevent the entry of foreign matter. Consequently, the main must be disinfected before it is put into service.

To obtain good results from disinfection and to avoid the hazards of subsequent obstructions and damage to valves, all foreign objects should be removed beforehand by swabbing and flushing clean the pipeline. Packing and jointing materials should also be cleaned and disinfected immediately before use by immersion in a 50-ppm chlorine solution for at least 30 minutes.

Flushing of the section of the water main can be combined with the hydrostatic pressure test for detecting faulty joints and leaks. Once this test is completed the pipeline should be flushed at a water velocity of at least 0.75 m per second. The presence of hydrants, air valves, gate valves and other openings in or near the section to be disinfected facilitates the injection and extraction of water for flushing and disinfection.

Recently developed plastic foam swabs are useful in the disinfection of mains. As they are displaced by the water pressure, these swabs wipe clean the inner surface of the pipe; they can also isolate the section to be disinfected from the rest of the main and prevent the loss of the disinfecting solution.

Chlorine compounds such as those described on pages 40 and 46 are the most commonly used for disinfecting water mains. The strength of the disinfecting solution should be much higher than that normally used for water chlorination. Under normal conditions, a strength of 10 ppm is recommended when the chlorine remains in the main for a period of 12-24 hours; application for 24 hours is necessary when the chlorine has to penetrate through organic matter coating the inner surface. In emergencies,

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\* See also: Cox, C. R. (1964) *Operation and control of water treatment processes*, Geneva (World Health Organization : Monograph Series, No. 49) pp. 161-165.

when it is not possible to leave a section of the main out of service for a long time, the period of contact can be shortened by proportionately increasing the strength of the solution; thus, for a contact period of 1 hour the strength of the solution should vary between 120 and 240 ppm.

When strong solutions are used, particular attention should be paid to their thorough removal from the main after completion of disinfection; illness and discomfort may result from using highly chlorinated water, and the corrosive action of the chlorine may damage pipes, valves, hydrants, and household plumbing and fixtures.

### **Procedures for application**

Chlorine gas may be injected directly into the section of the main by a dry-feed chlorinator supplied with a special gas diffuser or silver tube and attached to a hydrant or other opening by means of a special plug valve. After the section has been thoroughly flushed, the intake valve is partly shut to bring the water pressure below 1.7 kgf/cm<sup>2</sup> (25 lb/in<sup>2</sup>). At the hydrant or opening where the water is discharged the flow rate is measured to determine the rate at which chlorine gas needs to be delivered. To obtain a concentration of 10 ppm in the section to be disinfected, the chlorine gas input rate should be 0.9 kg/24 h for every litre per second of flow (0.12 lb/24 h for every US gal/min or 0.14 lb/24 h for every UK gal/min). The valve of the chlorine cylinder is opened and adjusted so that the dial shows the required rate of chlorine flow.

As soon as the odour of chlorine is detected in the water discharged from the main, water samples are taken to determine the chlorine content. The drop-dilution method is suitable for high concentrations of residual chlorine; if the orthotolidine method<sup>1</sup> is used, a deep red colour should be produced in the sample when the reagent is added. When the desired chlorine content is reached, the discharge hydrant is shut and the appropriate valves are turned to stop the flow of water and chlorine gas. The water so treated is allowed to stand in the main for 12-24 hours, after which the main should be thoroughly flushed until the water is clear and has no odour of chlorine.

A similar procedure is used for feeding a mixture of chlorine gas and water by means of a solution-feed chlorinator; a special rubber hose should be added to the plug valve and the silver-tube diffuser. A booster pump may be required to provide a pressure at least three times higher than that in the main, in order to ensure satisfactory injection of the solution.

When calcium hypochlorite or chlorinated lime is used for disinfecting a section of a main, the easiest method of application is to inject a strong chlorine solution by means of a portable chlorinator. If the intake valve is kept partly open, a small flow of water can enter the pipe to assist in the

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<sup>1</sup> *International standards for drinking-water*, Geneva, World Health Organization, 1963, p. 166.

dispersion of the chemical. The discharge hydrant or valve is shut off when the odour of chlorine is detected in the water flowing out, and the section of the main is allowed to fill. The intake valve is regulated so that the required amount of disinfecting solution is injected before the pipe is completely full.

When there is no chlorinator or pump to inject the disinfecting solution, the intake valve is shut off after the flushing operation and the section is allowed to drain dry; then the discharge hydrant or valve is shut off, thus leaving the section to be disinfected isolated from the rest of the main. The disinfecting solution is slowly poured through a funnel or hose into an intermediate hydrant, valve or opening made for this purpose, until the section is completely filled. Precautions should be taken to allow air trapped in the pipe to escape; where there is no air valve or other orifice by which the air can be released, one or more service connexions could be detached or a hole could be drilled in the top of the pipe.

If the section to be disinfected is short, weighed quantities of calcium hypochlorite or chlorinated lime in powder form may be placed at regular intervals inside the pipes while they are fixed into place; when water is introduced later, the powder will mix with it and produce strong concentrations of chlorine. The disadvantage is that the powder will be flushed to the far end of the section even when the water is admitted slowly, and no uniform distribution of the disinfectant is possible.

While the disinfecting solution remains in the pipes, the valves and hydrants in that section of the main should be operated to ensure that all surfaces come into contact with the disinfectant. The valves at either end of the treated section should remain shut during the whole period of contact to prevent the loss of disinfecting solution.

At the end of the contact period, samples of the disinfecting solution should be taken to check that the chlorine content has remained at the prescribed strength. The section should then be thoroughly flushed to remove the disinfecting solution. Samples for bacteriological tests should be taken every day during the 3 days following disinfection to ascertain that the operation was successful.

To ensure that the chlorine concentration remains at 10 ppm throughout the period of contact, the original strength of the solution should be at least twice as high (20 ppm). The following table shows the amount of disinfectants required for pipes of various diameters in order to provide a chlorine concentration of about 20 ppm.

The volume in litres of the disinfecting solution required for 100 m of pipe can be expressed by  $V_1 = 5.07 d^2$ , where  $d$  is the diameter of the pipe in inches.

The volume in US gallons of the disinfecting solution required for 100 yd of pipe can be expressed by  $V_2 = 1.22 d^2$ , where  $d$  is the diameter of the pipe in inches.

## SANITATION IN NATURAL DISASTERS

QUANTITY OF DISINFECTANTS REQUIRED TO PROVIDE  
A CONCENTRATION OF 20 ppm

Diameter of pipe		Chlorinated lime (25 % available chlorine)		Calcium hypochlorite (70 % available chlorine)		Sodium hypochlorite (5 % available chlorine)	
mm	in	g per 100 m	oz per 100 yd	g per 100 m	oz per 100 yd	litres per 100 m	US gal per 100 yd
75	3	37	1.2	13	0.4	0.18	0.05
100	4	65	2.1	23	0.7	0.33	0.08
150	6	146	4.8	53	1.7	0.73	0.18
200	8	260	8.4	92	3.0	1.30	0.31
250	10	405	13.4	145	4.7	2.03	0.49
300	12	584	19.2	210	6.8	2.92	0.66
400	16	1040	33.6	368	11.8	5.20	1.27

## Annex 9

### USEFUL DATA FOR VECTOR CONTROL OPERATIONS

The following tables are reproduced from the seventeenth report of the WHO Expert Committee on Insecticides.<sup>1</sup> It should be borne in mind that all pesticides are toxic to some degree. Care in handling them should therefore be routine practice and should form an integral part of programmes involving the application of pesticides. The use of such highly toxic rodenticides as sodium fluoroacetate, fluoroacetamide and thallium sulfate should be restricted to specially trained personnel already instructed in the safe handling of these compounds and in the treatment of poisoning by them. The general principles of safety measures to be observed in the use of pesticides are discussed in the report referred to above.<sup>2</sup>

**TABLE 1. PESTICIDES SUITABLE AS RESIDUAL SPRAY APPLICATIONS  
AGAINST MALARIA VECTORS**

Toxicant	Dosage in g/m <sup>2</sup>	Average duration of effectiveness (months)
DDT	1 or 2	6 to 12
dieldrin <sup>a</sup>	0.5	6 to 12
lindane	0.5	3
malathion	2	3
OMS-33	2	3

<sup>a</sup> Because of the hazard to man and domestic animals, the use of this insecticide has been abandoned by most countries. It has been found that in long-term programmes poisoning has occurred among spray operators, even when veils, caps and gloves were worn in addition to hats and overalls. Dieldrin should not be used for indoor spraying without full justification and unless strict precautionary measures and medical supervision are ensured.

<sup>1</sup> WHO Expert Committee on Insecticides (1970) *Insecticide resistance and vector control: seventeenth report*, Geneva (*Wld Hlth Org. techn. Rep. Ser.*, No. 443), Annex 18.

<sup>2</sup> *Ibid.*, pp. 258-267.

TABLE 2. PESTICIDES EMPLOYED AS LARVICIDES IN MOSQUITO CONTROL

Toxicant <sup>a, b</sup>	Dosage (g/ha)	Remarks
Abate	56-112	Use oil or water emulsion formulations in areas with minimum vegetative cover. Granular formulations are suitable for penetration of heavy vegetative cover.  For use as residual larvicides or pre-hatch treatments higher dosages are necessary.  <b>DO NOT APPLY PARATHION IN URBAN AREAS.</b> Apply Paris green pellets (5%) at rate of 16.8 kg/ha with ground machines or aircraft. Apply to cover water surface in catch basins or at a rate of 142-190 l/ha in open water courses. With a spreading agent the volume can be reduced to 19-47 l/ha. Apply at 19-47 l/ha.
DDT	224	
dieldrin	112	
Dursban <sup>c</sup>	11-16	
fenthion <sup>c</sup>	22-112	
fenitrothion	224-336	
heptachlor	112	
lindane	112	
malathion	224-672	
parathion	112	
parathion-methyl	112	
Paris green	840	
fuel oil		
larvicidal oil		

<sup>a</sup> As there may be regulations restricting the use of these compounds, the user should consult the appropriate authorities. He should also read the label carefully for any mention of restrictions on the type of persons approved for handling the compound or of hazard to non-target animals.

<sup>b</sup> Where insecticides are to be applied to croplands, pasture, range land, or uncultivated lands, the agricultural authorities should be consulted regarding acceptable application procedures.

<sup>c</sup> Dursban and fenthion should not be applied to waters containing valuable fish.

TABLE 3. PESTICIDES EMPLOYED AS EXTERIOR SPACE SPRAYS FOR MOSQUITO CONTROL

Toxicant	Dosage (g/ha)	Remarks
carbaryl	224-1120	The treatments are applied as thermal or non-thermal fogs, mists or dusts. Applications are most commonly made by ground equipment.  Environmental conditions, particularly wind movement, affect the efficacy of space treatments. Effective swath widths are usually from 30 to 90 m (100-300 ft).
DDT	224	
dichlorvos	56-280	
fenthion	112	
lindane	112-224	
malathion	112-560	
naled	56-280	

TABLE 4. ORGANOPHOSPHORUS COMPOUNDS  
USED AS RESIDUAL TREATMENTS IN FLY CONTROL

Toxicant <sup>a</sup>	Strength of finished formula-tion <sup>b</sup> (%)	Dosage (g/m <sup>2</sup> )	Remarks
diazinon	1.0-2.0	0.4-0.8	<b>AVOID CONTAMINATION OF FOOD AND DRINKING WATER</b> with any toxicant. Do not treat any milk room or food-processing plant when it is in operation. Can be used in all types of food-handling establishments <sup>c</sup> including the milk rooms of dairies. On poultry farms do not spray chickens or excreta that may come into contact with them.
dimethoate	1.0-2.5	0.4-1.6	Acceptable for dairy and poultry farm treatment but animals must be removed. Not to be used in milk rooms.
fenthion	1.0-2.5	0.4-1.6	Not acceptable in all countries for use in dairies, poultry houses, or food-processing plants.
Gardona	1.0-5.0	1.0-2.0	Can be used in dairies and other animal shelters but not acceptable for use in poultry houses in all countries.
malathion	5.0	1.0-2.0	Used in dairies, poultry houses and other food-handling establishments; <sup>c</sup> only premium grade malathion can be used in milk rooms and food-processing plants. On poultry farms treatment can be made without removing birds.
naled	1.0	0.4-0.8	Acceptable for application in dairies (except milk rooms) and in food-handling establishments. At 0.25 % strength can be applied to chicken roosts, nests, etc., without excluding the birds.
ronnel	1.0-5.0	1.0-2.0	Can be used in dairies including milk rooms, in food-handling establishments <sup>c</sup> and on poultry farms. <i>Removal of chickens during spraying is unnecessary but avoid spraying animals directly; do not spray excreta unless inaccessible to the chickens.</i>

<sup>a</sup> Read and follow directions on the label. For information on chemicals to be used against livestock or crop pests consult the national, state or local agricultural service or agency.

<sup>b</sup> Addition of sugar at 2.5 times the strength of toxicant increases the effectiveness of the treatment.

<sup>c</sup> Includes dairies, milk rooms, restaurants, canneries, food stores, warehouses and similar establishments.



TABLE 5. INSECTICIDES COMMONLY EMPLOYED IN CONTROL OF GERMAN COCKROACHES

Insecticide	Formulation	Concentration (%)
OMS-35	spray	1.0
	bait	2.0
chlordane	spray	2.0-3.0
	dust	6.0
diazinon	spray	0.5-1.0 <sup>a</sup>
	dust	2-5 <sup>a</sup>
dichlorvos	spray	0.5
	bait	1.9
dieldrin	spray	0.5 <sup>b</sup>
	dust	1.0
Dursban	spray	0.5 <sup>b</sup>
fenthion	spray	3.0 <sup>b</sup>
Kepone	bait	0.125
malathion	spray or dust	5.0

<sup>a</sup> Higher concentrations listed should be used by experienced personnel or pest control operators only.

<sup>b</sup> Pest control operators only.

TABLE 6. SINGLE-DOSE RODENTICIDES USED AGAINST NORWAY AND BLACK RATS

Compound	Acute oral dose <sup>a</sup> (mg/kg)	Percentage commonly employed in baits
antu <sup>b</sup>	6	1.5
arsenious oxide	13	1.5
fluoroacetamide	13-15	2.0
norbormide <sup>b</sup>	12	1.0
phosphorus, yellow	1.7	0.05
red squill <sup>b</sup>	500	10.0
sodium fluoroacetate	5 <sup>c</sup>	0.5
thallium sulfate	25	0.3-1.5
zinc phosphide	40	1.0-2.5

<sup>a</sup> Based on laboratory strains of *R. norvegicus*.

<sup>b</sup> Not used against black rats.

<sup>c</sup> 2 mg/kg for black rats.

TABLE 7. MULTIPLE-DOSE RODENTICIDES EMPLOYED AGAINST MICE, BLACK RATS AND NORWAY RATS

Rodenticide <sup>a</sup>	Dosage in parts per million <sup>b</sup>		
	Mice	Black rats	Norway rats
diphacinone	125-250	50-100	50-100
coumatufuryl	250-500	250-500	250
bindone			
warfarin	250-500	250-500	50-250

<sup>a</sup> May be used in dry or liquid bait.

<sup>b</sup> Dilution factors:

500 ppm (0.05 %) = 1 part of 0.5 % concentrate to 9 parts of bait.

250 ppm (0.025 %) = 1 part of 0.5 % concentrate to 19 parts of bait.

100 ppm (0.01 %) = 1 part of 0.5 % concentrate to 49 parts of bait.

50 ppm (0.005 %) = 1 part of 0.5 % concentrate to 99 parts of bait.

### Formulation of suspensions from water-dispersible powders

TABLE 8. AMOUNT OF WATER-DISPERSIBLE POWDER (w.d.p.) REQUIRED FOR PREPARATION OF SPRAY SUSPENSIONS

Percentage of toxicant in w.d.p.	Kg (lb) of w.d.p. required for about 380 litres (100 USgal; 83 UKgal) of finished spray suspension with concentrations of:				
	5 %	2.5 %	1 %	0.5 %	0.25 %
90	21.0 (46.3)	10.5 (23.1)	4.2 (9.3)	2.1 (4.6)	1.0 (2.3)
75	25.2 (55.6)	12.6 (27.8)	5.0 (11.1)	2.5 (5.6)	1.3 (2.8)
50	37.8 (83.3)	18.9 (41.7)	7.6 (16.7)	3.8 (8.3)	1.9 (4.2)
25	75.6 (166.7)	37.8 (83.3)	15.1 (33.3)	7.6 (16.7)	3.8 (8.3)

The general formula is:

$$X = \frac{A \times B \times D}{C}$$

in which X = amount of water-dispersible powder required

A = percentage concentration desired

B = quantity of spray desired

C = percentage concentration of water-dispersible powder

D =  $\begin{cases} 1 & \text{if X and B are expressed in kg and litres, respectively} \\ 8.33 & \text{if X and B are expressed in lb and USgal, respectively} \\ 10 & \text{if X and B are expressed in lb and UKgal, respectively} \end{cases}$

*Example* : 380 litres (100 USgal) of 1 % spray suspension are to be prepared from 50 % powder.

$$X = \frac{1 \times 380 \times 1}{50} = 7.6 \text{ kg} \quad (X = \frac{1 \times 100 \times 8.33}{50} = 16.7 \text{ lb})$$

7.6 kg (16.7 lb) of water-dispersible powder are required.

### Formulation of emulsion concentrates and sprays

TABLE 9. PREPARATION OF EMULSION CONCENTRATES FROM TECHNICAL MATERIAL

Concentration desired (%)	Weight of technical material required to make the following volumes of concentrate: <sup>a</sup>		
	100 litres	100 USgal	100 UKgal
35	35 kg	292 lb	350 lb
25	25 kg	208 lb	250 lb
15	15 kg	125 lb	150 lb
12.5	12.5 kg	104 lb	125 lb
6.25	6.25 kg	52 lb	62.5 lb

<sup>a</sup> To every 100 parts of concentrate 2 parts of emulsifier should be added.

The general formula is:

$$X = \frac{A \times B \times C}{100}$$

in which X = amount of technical material required

A = percentage concentration desired

B = quantity of emulsion concentrate desired

C =  $\begin{cases} 1 & \text{if X and B are expressed in kg and litres, respectively} \\ 8.33 & \text{if X and B are expressed in lb and USgal, respectively} \\ 10 & \text{if X and B are expressed in lb and UKgal, respectively} \end{cases}$

*Example* : 190 litres (50 USgal; 41.5 UKgal) of 25 % concentrate are to be prepared from technical grade material.

$$X = \frac{25 \times 190 \times 1}{100} = 47.5 \text{ kg} \quad (X = \frac{25 \times 50 \times 8.33}{100} = 104 \text{ lb})$$

47.5 kg (104 lb) of technical material are required.

TABLE 10. PREPARATION OF EMULSION FROM CONCENTRATES OF DIFFERENT STRENGTHS

Percentage of toxicant in emulsion concentrate	Parts of water to be added to 1 part of E.C. when concentration of final form is:				
	5 %	2.5 %	1 %	0.5 %	0.25 %
80	15	31	79	159	319
60	11	23	50	119	239
50	9	19	49	99	199
25	4	9	24	49	99
10	1	3	9	19	39

The general formula is:

$$X = \frac{A}{B} - 1$$

in which X = parts of water to be added to 1 part of emulsion concentrate

A = concentration of the emulsion concentrate (%)

B = required concentration of the final formulation (%)

*Example* : A 0.5 % formulation is to be prepared from a 25 % concentrate:

$$X = \frac{25}{0.5} - 1 = 49$$

49 parts of water to 1 part of concentrate are required.

**Amount of formulation required to give a specific weight of toxicant per unit area**

**TABLE 11. REQUIREMENTS FOR SPRAY FORMULATIONS**

Dosage (weight per unit area)	Litres <sup>a</sup> of spray required per 100 m <sup>2</sup> (1000 ft <sup>2</sup> ) using following concentrations of technical insecticide:				
	0.25 %	0.5 %	1.0 %	2.5 %	5.0 %
2 g/m <sup>2</sup> (200 mg/ft <sup>2</sup> )	—	—	20	8	4
1 g/m <sup>2</sup> (100 mg/ft <sup>2</sup> )	—	20	10	4	2
0.5 g/m <sup>2</sup> (50 mg/ft <sup>2</sup> )	20	10	5	2	1
0.2 g/m <sup>2</sup> (20 mg/ft <sup>2</sup> )	8	4	2	0.8	0.4

<sup>a</sup> 1 litre is approximately equal to 0.25 USgal or 0.2 UKgal.

**TABLE 12. REQUIREMENTS FOR EMULSION CONCENTRATE AND DUST**

Dosage		Amount of 25 % concentrate required		Amount of 5 % dust required	
kg/ha	lb/acre			kg	lb
4.54	10	18.2 litres	4.8 USgal 4.0 UKgal	90.8	200
2.27	5	9.1 litres	2.4 USgal 2.0 UKgal	45.4	100
1.36	3	5.5 litres	1.4 USgal 1.2 UKgal	27.2	60
1.0	2.2	4.2 litres	1.1 USgal 0.9 UKgal	20.0	44
0.45	1	1.8 litres	1.9 USqt 1.6 UKqt	9.1	20
0.23	0.5	900 ml	1.9 USpt 1.6 UKpt	4.5	10
0.045	0.1	200 ml	6.1 USfl oz 6.4 UKfl oz	—	—

<sup>a</sup> Containing 0.25 kg/litre (2.1 lb/USgal; 2.5 lb/UKgal).

The general formulae are:

$$\text{for concentrates } X = \frac{A \times 100}{B \times C}$$

$$\text{for dusts } X = \frac{A \times 100}{B}$$

in which X = amount of concentrate or dust required

A = dosage (kg per ha or lb per acre)

B = percentage concentration of the product used

C =  $\begin{cases} 1 & \text{if X and A are expressed in litres and kg, respectively} \\ 8.33 & \text{if X and A are expressed in USgal and lb, respectively} \\ 10 & \text{if X is expressed in UKgal} \end{cases}$

Examples : For a dosage of 4.54 kg per ha (10 lb per acre),

(a) using a 25 % concentrate,

$$X = \frac{4.54 \times 100}{25 \times 1} = 18.2 \text{ litres (X = } \frac{10 \times 100}{25 \times 8.35} = 4.8 \text{ USgal)}$$

18.2 litres of concentrate are required per ha or 4.8 USgal of concentrate are required per acre.

(b) using a 5 % dust,

$$X = \frac{4.54 \times 100}{5} = 90.8 \text{ kg (X = } \frac{10 \times 100}{5} = 200 \text{ lb)}$$

90.8 kg of dust per ha or 200 lb of dust per acre are required.

### Conversion tables for dosages in parts per million

TABLE 13. CONCENTRATIONS OF TOXICANT EQUIVALENT TO ONE PART PER MILLION

- 1 mg (0.015 grain) per kg
- 1 g (15.4 grains) per metric ton
- 0.007 grain (0.45 mg) per lb
- 1 ml (0.035 UKfl oz) per 1000 litres
- 0.16 UKfl oz (4.5 ml) per 1000 UKgal
- 0.13 USfl oz (3.8 ml) per 1000 USgal

TABLE 14. DILUTION FACTORS FOR 25 % CONCENTRATE

Required concentration (ppm)	Volume of 25 % concentrate <sup>a</sup> needed for the following volumes of water:		
	1 million litres	1 million USgal	1 million UKgal
1	4 litres	4 USgal	4 UKgal
0.1	400 ml	3.2 USpt	3.2 UKpt
0.01	40 ml	5.1 USfl oz	6.5 UKfl oz
0.001	4 ml	0.5 USfl oz	0.6 UKfl oz

<sup>a</sup> Containing 0.25 kg/litre (2.1 lb/USgal; 2.5 lb/UKgal).

TABLE 15. RELATIONSHIP OF CONCENTRATION TO TREATMENT DOSAGE AND WATER DEPTH

Treatment dosage		Concentration (ppm) at depth of <sup>a</sup>	
g/ha	lb/acre	2.5 cm (1 in)	30 cm (1 ft)
2240	2.0	8.8	0.74
1120	1.0	4.4	0.37
560	0.5	2.2	0.18
280	0.25	1.1	0.092
112	0.10	0.44	0.037
56	0.05	0.22	0.018
28	0.025	0.11	0.0092
11	0.01	0.044	0.0037

<sup>a</sup> The ppm concentration at other depths or other treatment dosages can be obtained by simple proportion; for example, the ppm concentration at depths of 10 and 20 cm are 1/4 and 1/8, respectively, of those at 2.5 cm.

### Area measurements for space applications

TABLE 16. NUMBER OF HECTARES IN AREAS <sup>a</sup> OF DIFFERENT DIMENSIONS

Length of area (m)	Number of ha in areas of the following widths:			
	25 m	50 m	100 m	500 m
1600	4.0	8.0	16.0	80.0
1000	2.5	5.0	10.0	50.0
600	1.5	3.0	6.0	30.0
400	1.0	2.0	4.0	20.0
250	0.63	1.25	2.5	12.5

<sup>a</sup> Other values can be determined by simple proportion or by the formulae:

$$\text{Hectares} = \frac{\text{length (m)} \times \text{width (m)}}{10000} \text{ or } \frac{\text{length (km)} \times \text{width (m)}}{10}$$

$$\text{Acres} = \frac{\text{length (ft)} \times \text{width (ft)}}{43560} \text{ or } 0.121 \times \text{length (miles)} \times \text{width (ft)}$$

TABLE 17. AERIAL SPRAY COVERAGE  
IN RELATION TO SPEED OF AIRCRAFT AND SWATH WIDTH

Speed of aircraft <sup>a</sup>		Aerial spray coverage per minute for swath widths of:				
km/h	mi/h	15.2 m (50 ft)	22.9 m (75 ft)	30.5 m (100 ft)	61.0 m (200 ft)	152.4m(500ft)
128	80	3.2 ha 8 acres	4.9 ha 12 acres	6.5 ha 16 acres	12.9 ha 32 acres	32.4 ha 80 acres
144	90	3.6 ha 9 acres	5.5 ha 13.5 acres	7.3 ha 18 acres	14.2 ha 36 acres	36.4 ha 90 acres
160	100	4.0 ha 10 acres	6.1 ha 15 acres	8.1 ha 20 acres	16.2 ha 40 acres	40.5 ha 100 acres
192	120	4.9 ha 12 acres	7.3 ha 18 acres	9.7 ha 24 acres	19.4 ha 48 acres	48.6 ha 120 acres
240	150	6.1 ha 15 acres	9.1 ha 22.5 acres	12.1 ha 30 acres	24.3 ha 60 acres	60.7 ha 150 acres

<sup>a</sup> 1 knot = 1.85 km/h = 1.15 mi/h.

Other coverage values can be determined by simple proportion or by the formulae:

Hectares per minute = (swath width in m) × (km per hour) × 0.00166

Acres per minute = (swath width in ft) × (miles per hour) × 0.002. Based on the area an aircraft covers per minute the spray system is calibrated to disperse the desired amount of pesticide per unit area. To find the rate of pesticide dispersal required per minute multiply the area covered per minute by the amount of pesticide to be applied per unit area.

*Example* : A volume of 220 ml per hectare is to be applied from an aircraft which covers 4.0 hectares per minute:

$$220 \times 4.0 = 880$$

The aircraft is calibrated to deliver 880 ml per minute.

### Conversion factors : metric, British and US units

#### Length

1600 m	= 1.6 km	= 1 mile	= 1760 yd = 5280 ft
$1 \times 10^5$ cm	= 1000 m	= 1 kilometre (km)	= 0.625 mile = 1100 yd
91.4 cm	= 0.91 m	= 1 yard (yd)	= 3 ft = 36 in
1000 mm	= 100 cm	= 1 metre (m)	= 1.093 yd = 3.28 ft = 39.37 in
0.3048 m	= 30.48 cm	= 1 foot (ft)	= 12 in
25.4 mm	= 2.54 cm	= 1 inch (in)	= 1/12 ft
10 000 $\mu$	= 10 mm	= 1 centimetre (cm)	= 0.394 in = 0.033 ft
1000 $\mu$		= 1 millimetre (mm)	= 0.0394 in
0.001 mm	= 0.0001 cm	= 1 micron ( $\mu$ )	= 0.000039 in (about 1/25 000 in)

**Area**

	259 ha	≈ 1 square mile (sq mile)	≈ 640 acres
	100 ha	≈ 1 square kilometre (km <sup>2</sup> )	≈ 0.39 sq mile = 247 acres
10 000 m <sup>2</sup>	≈ 0.01 km <sup>2</sup>	= 1 hectare (ha)	≈ 2.47 acres
4047 m <sup>2</sup>	≈ 0.405 ha	= 1 acre	≈ 4840 yd <sup>2</sup> ≈ 43 560 ft <sup>2</sup>
	10 000 cm <sup>2</sup>	≈ 1 square metre (m <sup>2</sup> )	≈ 1.2 yd <sup>2</sup> = 10.76 ft <sup>2</sup> ≈ 1550 in <sup>2</sup>
	0.84 m <sup>2</sup>	= 1 square yard (yd <sup>2</sup> )	≈ 9 ft <sup>2</sup> ≈ 1296 in <sup>2</sup>
930 cm <sup>2</sup>	≈ 0.093 m <sup>2</sup>	= 1 square foot (ft <sup>2</sup> )	≈ 144 in <sup>2</sup>
	6.45 cm <sup>2</sup>	= 1 square inch (in <sup>2</sup> )	≈ 0.007 ft <sup>2</sup>
	100 mm <sup>2</sup>	≈ 1 square centimetre (cm <sup>2</sup> )	≈ 0.155 in <sup>2</sup>
	93 m <sup>2</sup>	≈ 1000 square feet (ft <sup>2</sup> )	

**Volume**

1000 litres	≈ 1 cubic metre (m <sup>3</sup> )	≈ 1.307 yd <sup>3</sup> = 35.32 ft <sup>3</sup>
2.83 m <sup>3</sup>	≈ 100 cubic feet (ft <sup>3</sup> )	≈ 3.7 yd <sup>3</sup>
0.77 m <sup>3</sup>	≈ 1 cubic yard (yd <sup>3</sup> )	≈ 27 ft <sup>3</sup>
28.32 litres	≈ 1 cubic foot (ft <sup>3</sup> )	≈ 0.037 yd <sup>3</sup> ≈ 1728 in <sup>3</sup>
16.39 cm <sup>3</sup>	≈ 1 cubic inch (in <sup>3</sup> )	≈ 0.000579 ft <sup>3</sup>

**Liquid capacity**

3.79 litres	≈ 1 US gallon (USgal)	≈ 0.83 UKgal ≈ 231 in <sup>3</sup>
4.55 litres	≈ 1 UK gallon (UKgal)	≈ 1.2 USgal
1000 ml	≈ 1 litre	≈ 0.26 USgal (0.22 UKgal)
32 USfl oz	≈ 1 US quart (qt)	≈ 0.9463 litre
Approx. 40 UKfl oz	≈ 1 UKqt	≈ 1.136 litres
3 teaspoonfuls	≈ 1 tablespoonful	≈ 0.5 USfl oz

**Weight**

1000 mg	≈ 1 gram (g)	≈ 0.0352 oz
28.35 g	≈ 1 ounce (oz)	≈ 1/16 lb ≈ 437.5 grains
64.8 mg	≈ 1 grain	≈ 1/7000 lb
453.6 g	≈ 1 pound (lb)	≈ 16 oz
1000 g	≈ 1 kilogram (kg)	≈ 2.2 lb = 35.27 oz
1000 kg	≈ 1 metric ton	≈ 2204 lb
907 kg	≈ 1 US short ton	≈ 2000 lb ≈ 0.893 UK ton
1018 kg	≈ 1 UK ton	≈ 2240 lb ≈ 1.12 US short tons
	(1 US long ton)	

**Weight of water in various volumes at 16.7°C (62°F)**

1 ft <sup>3</sup>	≈ 62.3 lb
1 litre	≈ 1000 g, 1 kg, 2.2 lb
1 USgal	≈ 8.33 lb
1 UKgal	≈ 10 lb



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