CHAPTER 9: WATER

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Need

Water is essential to life and health. In emergencies it is often not available in adequate quantity or quality, thus creating a major health hazard.

Aim

To provide enough safe water for the refugees and to meet communal needs.

Principles of response

- [ ] Seek expert advice, co-ordinate closely with the appropriate national services and involve the refugees.
- [ ] Ensure consideration of the water supply at the site selection and planning stage and co-ordinate response closely with public health and environmental sanitation measures.
- [ ] Provide a reserve supply and spare capacity, to meet temporary difficulties and the needs of new arrivals.
- [ ] Take account of seasonal variations.
- [ ] If at all possible, avoid the need to treat water.

Action

- [ ] Organize an immediate, competent assessment of water supply possibilities in relation to needs.
- [ ] Protect existing sources of water from pollution.
- [ ] Develop sources and a storage and distribution system that supplies a sufficient amount of safe water, including a reserve.
- [ ] Ensure regular testing of water quality.

9.1 Introduction

1. Safe water is essential to life and health. People can survive longer without food than without water. Thus the provision of water demands immediate attention from the start of a refugee emergency. The aim is to assure availability of enough water to allow unrestricted distribution, and to ensure that it is safe to drink. Adequate storage capacity and back-up systems for all aspects of water supply must be assured, since interruptions in the supply may be disastrous. To avoid contamination, all sources of water used by refugees must be separated from sanitation facilities and other sources of contamination. As a rule, in this as in other sectors, the simplest possible technologies are the most appropriate in refugee emergencies.

2. Availability will generally be the determining factor in organizing the supply of sufficient quantities of safe water. It may be necessary to make special arrangements for extraction of the water, storage and distribution. Measures will be required to protect the water from contamination and in some circumstances treatment will be needed to make the water safe to drink. The safety of the water must be assured right through to consumption in the home. The dangers of drinking contaminated water are discussed in 9.7.1.

3. Improvements in the existing water supply may take time, particularly where it is necessary to drill or dig wells. In many refugee emergencies only contaminated surface water (standing water, streams or rivers) is initially available and immediate action must be taken to stop further pollution and reduce contamination. If it is evident that available sources are inadequate, arrangements must be made to bring in water by truck. Where even the most basic need for water cannot safely be met from existing sources in the area, and when time is needed for further exploration and development of new sources, the refugees should be moved to a more suitable location. Figure 9-1 overleaf shows some of the considerations in diagrammatic form.

4. Water and sanitation are the subjects of separate chapters. The considerations are, however, largely interdependent and this chapter should be read in conjunction with chapter 10 on sanitation.

9.2 Assessment and organization

- An immediate, competent assessment of local water supply possibilities, involving the government authorities, is essential.

- Expertise is required, and local knowledge is most important.

- Involve the refugees, use their special skills and train them to operate and maintain the system.

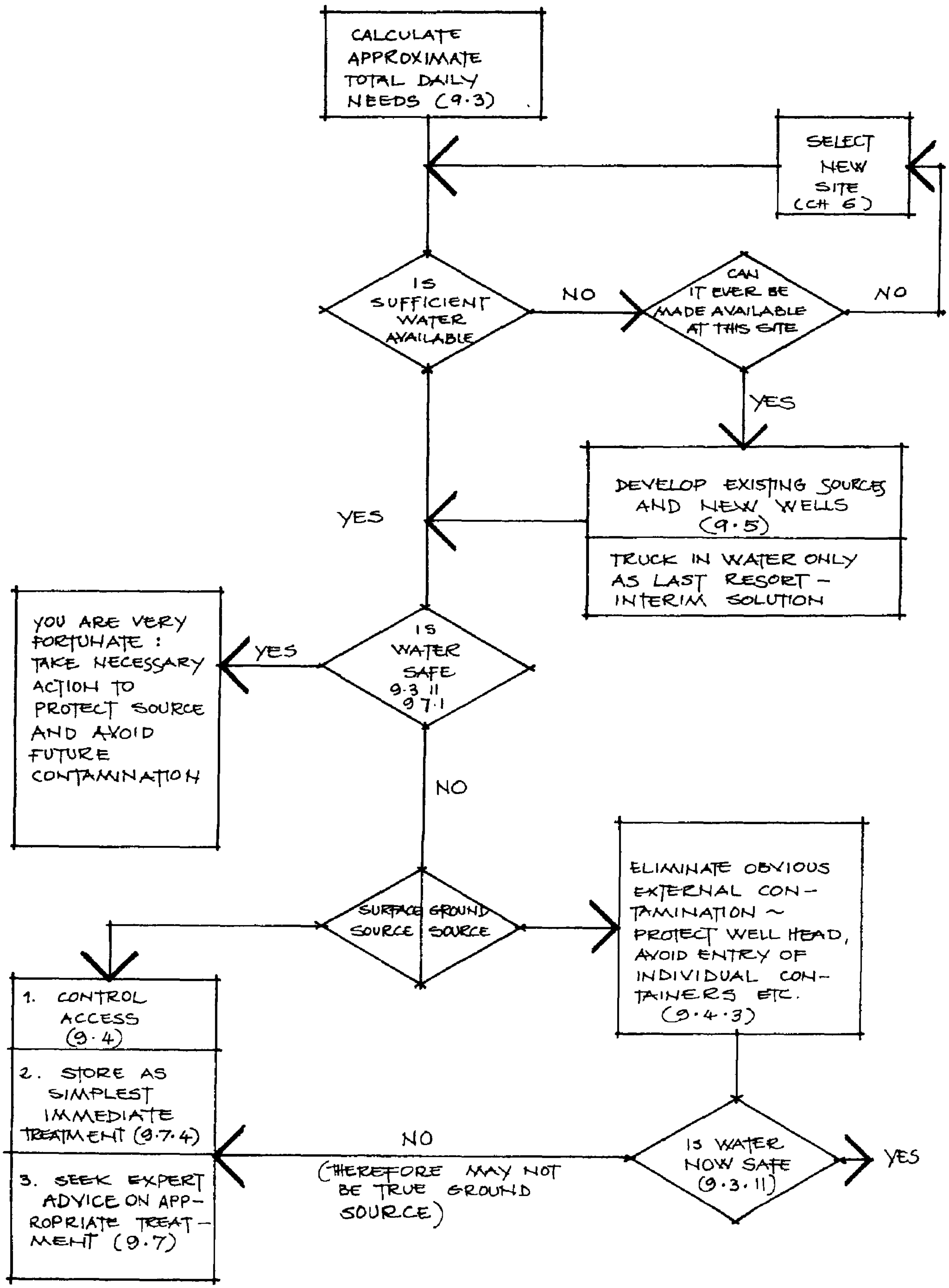
- Technology and equipment should be simple, reliable, appropriate and familiar to the country.

General

1. An immediate on-the-spot assessment of local sources of water in relation to needs is essential. The government's central and local water authorities and experts should be involved in this assessment. Knowledge of the local terrain and conditions is indispensable and expertise from outside the country should be brought in only when clearly necessary. An influx of refugees may over-strain water resources used by the local population.

2. Available sources must be protected from pollution at once. Rationing of scarce water may be needed initially in order to ensure survival of the weak and equity in distribution to the rest of the refugee population. The

9-1 GENERAL CONSIDERATIONS IN EMERGENCY WATER SUPPLY



design, establishment and functioning of a water supply and distribution system must be closely co-ordinated with the site planning and layout and with health and environmental measures, and in particular sanitation.

Assessment

3. While estimating the need for water does not require special expertise, assessment of supply possibilities does. A distinction may be useful between the identification of sources on the one hand, and their development and exploitation on the other. Depending on the situation, sources of water and their characteristics may be identified by: the local population; the refugees themselves; the lie of the land (ground water is often near the surface in the vicinity of rivers and in low places generally, or is indicated by richer vegetation); maps and surveys of water resources; and national and expatriate experts (hydrologists); water diviners may be useful. The assessment of water sources, which must be the basis for decisions on a water supply and distribution system generally, requires expertise in water engineering, sanitation (testing, purification) and in some cases logistics.

4. Seasonal factors must be carefully considered. Supplies that are adequate in the rainy season may dry up at other times. Local knowledge will be essential.

Personnel and material

5. Local sources of information and expertise are best and may include: central and local government departments (e.g. interior, public works, agriculture, water resources), the UN system, especially UNICEF, bilateral aid programmes, NGOs and engineering consultants and contractors. If it is clear that locally available expertise will not suffice, Headquarters' assistance should be requested without delay. If outside assistance is necessary, this should be provided whenever possible in support of local experts. Where a water supply and distribution system has to be established with the help of expatriates and mechanized technology, running and maintenance by refugees and other local personnel must be assured before the departure of the expatriates. If this is not done, even the best system will break down.

6. As the provision of safe water is essential to the health of the community, and impossible without its understanding and cooperation, the system must be developed with the refugees and operated by them from the start to the extent possible. The refugees, particularly if of rural background, may themselves have relevant skills. For example, some rural communities contain individuals who are expert at digging and maintaining wells. Others may be familiar with simple pumps or common pump motors. Such skills must be fully utilized in planning, developing and operating the water system. Refugees without prior experience should be trained as necessary. Basic public health education, for example on the importance of avoiding pollution of the water by excreta and the use of clean containers in the home, will be essential.

7. While special equipment may be required in the exploration for new ground water sources or for purification of surface water, material and equipment to establish a water supply and distribution system should be found locally to the maximum possible extent. As a general rule, technology should be kept simple. It should be appropriate to the country and draw on local experience. Where pumps and other mechanical equipment are unavoidable, supplies should be standardized as far as possible, with local familiarity, availability of spares and fuel and ease of maintenance the priority considerations.

8. Both organizational and technical aspects of the complete water supply system need to be carefully monitored. Use of the system must be controlled and water wastage or contamination prevented, maintenance must be assured, and technical breakdowns quickly repaired.

9.3 The need

- [ ] Calculate on at least 15 litres per person per day plus communal needs and a spare capacity for new arrivals.

- [ ] To preserve public health, a large amount of reasonably pure water is preferable to a smaller amount of very pure water.

- [ ] The water must nevertheless be safe: test new sources before use and periodically thereafter, and immediately following any outbreak of a disease which might be caused by unsafe water.

Quantity

1. Minimum water needs will vary with each situation and will increase markedly with air temperature and physical exercise. As a general indication, the following amounts of water are desirable:

Individuals:
15-20 litres per person/day;

Health centres:
40-60 litres per patient/day;

Feeding centres:
20-30 litres per patient/day.

Further needs may include livestock, sanitation facilities, other community services, and irrigation. The more convenient the supply, the higher will be consumption.

2. Reduction in the quantity of water available to individuals directly affects their health. As supplies are reduced, clothes cannot be washed, personal hygiene suffers, cooking utensils cannot be properly cleaned, food cannot be adequately prepared and finally the direct intake becomes insufficient to replace moisture lost from the body. The reduction is reflected in increased incidence of parasitic, fungal and other skin diseases, eye infections, diarrhoeal diseases and the often fatal dehydration associated with them. Even those individuals who may have traditionally lived on less than the normally recommended amount of water, for example nomads, will require more in a refugee community because of crowding and other environmental factors.

3. The needs of community services vary widely, for example from sufficient water to swallow a pill and wash hands in a health centre to the large quantities required in a health centre. Proper supplementary and therapeutic feeding programmes will be impossible unless sufficient water is available for preparation of food and for basic hygiene.

4. The availability of water will be a factor in deciding on a sanitation system. For example, one aquaprivy has a water tank volume of 1,000 litres, to which some five litres per user must be added daily to maintain the water seal; the Oxfam Sanitation Unit requires up to 3,000 litres per day to serve 1,000 persons.

5. Water will be needed for any livestock but care should be taken to avoid pollution or depletion of scarce water sources by livestock. As a rule of thumb, cattle need about 30 litres of water daily and small stock about five.

6. Water for irrigation will be necessary for the cultivation of food by the refugees. In the initial stages of an emergency, only waste water after domestic use may be available, and may suffice for small vegetable patches. Large-scale irrigation is a matter for

expert advice and not considered here, though sources should be identified and reserved at an early stage if possible.

7. Water will probably be of little use in controlling major fires on refugee sites owing to a lack of sufficient quantity and pressure.

8. If more refugees are likely to arrive, plans must allow for a substantial spare capacity over present needs. As has been explained in chapter 6, water is often the determining factor in both site selection and site capacity.

Quality

9. The water must be both acceptable to the refugees and safe to drink. If it tastes and looks acceptable, it will be drunk, with the main dangers being from microbiological organisms. However these "water-borne" diseases are not usually as serious or widespread a problem as the "water-washed" diseases, such as skin and eye infections and diarrhoea, which result from insufficient water for personal hygiene. Thus a large quantity of reasonably safe water is preferable to a smaller amount of very pure water. The most serious threat to the safety of a water supply is contamination by faeces: once the water has been contaminated it is hard to purify quickly under emergency conditions. Possible treatment measures are considered in section 9.7.

10. Where drinking water is scarce, brackish or even salt water, if available, may have to be used for domestic hygiene.

11. New water supplies should be tested before use, and existing ones periodically, and immediately after an outbreak of a typically water-borne disease. The most useful tests are those that detect and enumerate common faecal bacteria, such as faecal coliforms, Escherichia coli or faecal streptococci. The presence of any of these indicates that the water has been contaminated by faeces of humans or other warm-blooded animals. The actual test done will depend on the normal practice of local water laboratories and the experience of the local sanitarians. The most widely used tests are those that detect and enumerate faecal coliforms. Concentrations of faecal coliforms are usually expressed per 100 ml of water. As a rough guide:

0-10	faecal coliforms/100ml = reasonable quality
10-100	faecal coliforms/100ml = polluted
100-1,000	faecal coliforms/100 ml = very polluted
over 1,000	faecal coliforms/100 ml = grossly polluted

In cases where the water is disinfected by chlorination (9.7.9.) it is easier and more appropriate to test for the presence of free chlorine than for bacteria. The presence of free chlorine at around 0.2 mg/l at the distribution point indicates that the bacteria have almost certainly been killed and that the water cannot be heavily polluted with faecal or other organic matter.

12. The water in storage tanks and any tanker trucks should also be tested periodically. The water must, of course, be safe at the time of consumption or use in the home, not just at the distribution point. Domestic hygiene and environmental health measures to protect the water between collection and use are important.

9.4 Immediate response

☐ If even the minimum amount of water cannot be made available in time from local sources, the refugees should be moved.

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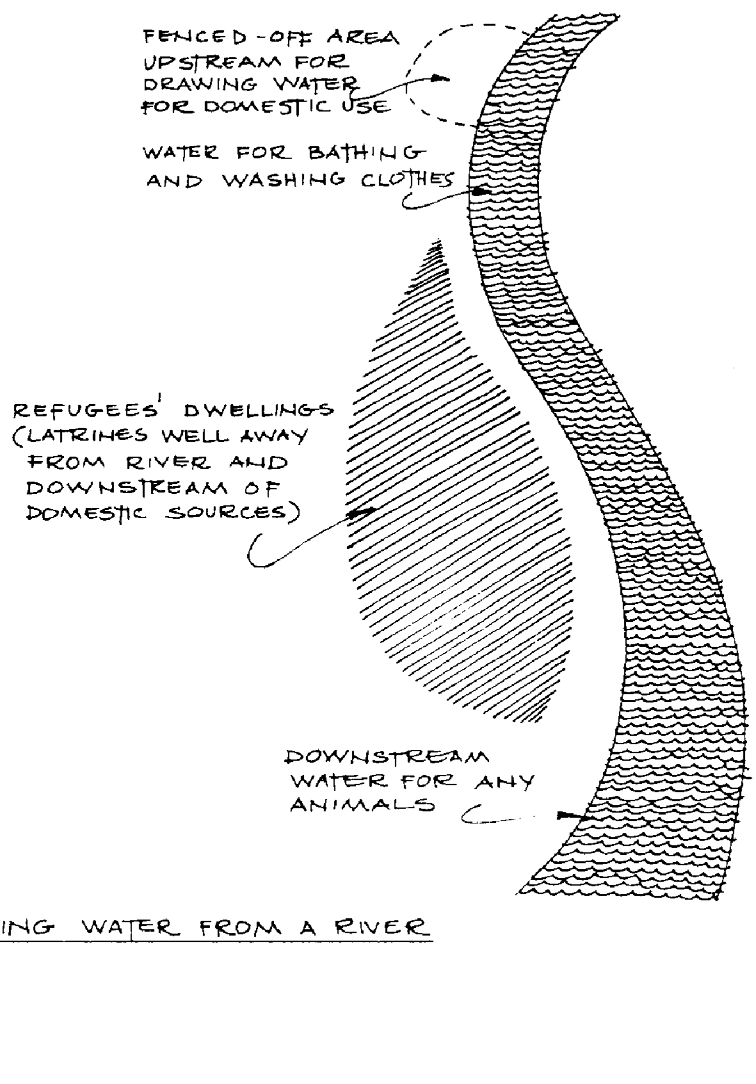
☐ Whatever the water source, take immediate action to prevent pollution by excreta.

☐ Organize a distribution system that prevents pollution of the source and ensures equity if there is insufficient water.

1. Short-term emergency measures may be necessary while the longer term supply system is being developed or pending the move of the refugees to a more suitable site. If the locally available water supply is insufficient to meet the minimum needs of the refugees, arrangements must be made to bring in water by truck. If this is not possible, the refugees must be moved without delay. Often, however, the quantity of water available will meet initial minimum needs and the immediate problem is its quality: it is likely to be dangerously contaminated.

2. The refugees will be using either surface water or, less often, ground water (well or spring). This is usually whatever water is closest, regardless of quality. The best immediate response is likely to be organizational and should be arranged with the refugee community leaders. Whatever the water source, take immediate steps to prevent pollution by excreta. If the source is flowing, supplies must be drawn off upstream and a special area set aside for this. Then allocate an area for washing and finally, downstream of the settlement, allow any livestock to water. See figure 9-2. Fence off parts of the river bank as necessary, and beware of any dangers in the water, such as crocodiles.



9-2 DRAWING WATER FROM A RIVER

3. Where the source is a well or spring, fence off, cover and control the source. Prevent refugees drawing water with individual containers which may contaminate the source. If possible make immediate arrangements to store water and to distribute it at collection points away from the source. Not only does this help avoid direct contamination but storage can make water safer.

4. At the same time, action must be taken to improve the quantity from existing sources and the effectiveness of any distribution system.

5. From the start, families will need to be able to carry and store water at the household level. Suitable containers (10-20 litres) are essential. Sometimes empty cooking oil containers or the like are available but if not, buckets or other containers must be supplied. These must be kept clean.

6. If the immediately available supplies of water are insufficient, action to ration supplies and ensure equitable distribution will be a priority. Rationing is difficult to organize. The first step is to control access to the sources, using full-time watchmen if necessary; uncontrolled distributions are open to abuse. Distribution at fixed times for different sections of the site should be organized. Vulnerable groups may need special arrangements. Every effort must be made to increase the quantity of water available so that strict rationing is unnecessary.

7. In parallel to these steps, action must be set in hand to plan how the need for water may best be met in the longer term and implementation of this plan set in hand as soon as possible. The following sections outline the main considerations.

9.5 Water sources and their protection

- [ ] Rain water, ground water from springs and wells, and water from municipal and private systems is usually of better quality than surface water from sources such as rivers, lakes or dams, and should be used if available.

- [ ] Physical protection of the source from pollution will be essential.

- [ ] Avoid sources that require treatment if at all possible.

- [ ] Expert advice and local knowledge are necessary before sinking wells.

- [ ] New or repaired sources and equipment should be disinfected.

General

1. There are three main natural types of fresh water: surface water (streams, rivers, lakes), ground water (underground or emerging at springs) and rain water. Considerations in choosing between alternative sources of water in an emergency include:

(1) speed with which source can be made operational;

(2) volume of supply;

(3) reliability of supply (taking into account seasonal variations and, if necessary, logistics);

(4) water purity, risk of contamination and ease of treatment if necessary;

(5) rights and welfare of local population;

(6) simplicity of technology and ease of maintenance;

(7) cost.

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2. Take careful account of systems and methods already in use locally. Adoption of well-proven and familiar techniques, combined with action to improve protection against pollution, is often a sound solution.

3. In addition to organizational measures to protect the water supply, some form of treatment may be necessary. However, sources which would require treatment should be avoided if at all possible. The purification of unsafe water, particularly in remote areas, can be difficult and requires trained supervision to be reliable. The following paragraphs provide general information on different sources of water and indicate the likely need for treatment. Table 9-3 shows some of the considerations.

Surface water

4. Water from streams, rivers, ponds, lakes, dams and reservoirs is rarely pure, and its direct use is likely to require treatment measures; direct access may also cause difficulties with the local population. However, where such a source holds water year-round, the water table in the vicinity can be expected to be near the surface. It is generally preferable to use such ground water, as it will have passed through the natural filter of the soil, rather than the surface water directly. One or more suitable types of well may be used. If the ground is not sufficiently porous to allow extraction of enough water from wells, surface water may be the only option. In such circumstances, emergency treatment measures such as storage, sand filtration or even chlorination will probably be necessary. If surface water must be used, the physical control of access described in 9.4.2 is essential.

Springs

5. Springs are the ideal source of ground water. Water from a spring is usually pure at the source and can be piped to storage and distribution points. It should be taken off above the site if possible. Care should nevertheless be taken to check the true source of spring water, as some apparent springs may really be surface water which has seeped or flowed into the ground a short distance away. It is essential that spring water be protected against pollution at the source by means of a simple structure built of bricks, masonry or concrete, from which the water flows directly through a pipe to a tank or collection point. Care must also be taken to prevent contamination above the take-off point. The supply of water from a spring may vary widely with the seasons and will be at its minimum at the end of the dry season: seek local advice.

Other ground water

6. If the need for water cannot be met by springs, the next best option is to raise ground water by means of tube wells, dug wells or boreholes. Ground water, being naturally filtered as it flows underground, is usually microbiologically pure. The choice of method will depend on circumstances in each case, including the depth of the water-table, yield, soil conditions and availability of expertise and equipment. Table 9-4 on page 128 gives some basic characteristics of the different types of wells.

7. Without good water resource surveys, preliminary test drilling or clear local evidence from nearby existing wells, there is no assurance that new wells will yield the necessary amount of water of the right quality. They can also be expensive. A hydrogeological survey must be undertaken before starting any extensive drilling programme. It is often better to try and improve an existing well that has an inadequate yield rather than dig a new one.

9-3 Some general considerations related to water sources

Source	Treatment (1) (see 9.7)	Extraction (see 9.6)	Distribution (see 9.6)	Remarks
A. Rain	Unnecessary	Simple: off suitable roofs	Individual collection	Seasonal, unlikely to meet total demand. See 9.5.11
Ground water				
B. Spring	Unnecessary	Simple: controlled access	Individual collection or via storage tanks, optionally through piped system	Yield may vary seasonally
C. Deep well (low water table, outside assistance may be required. Each well likely to serve more people than D)	Unnecessary	Hand pump if possible motorized if necessary	As for B	See table 9-4
D. Shallow well (high water table, likely to be many, often self-dug)	Unnecessary if properly located, constructed and maintained	Hand pump or hand drawn container	Individual collection	As for B
Surface water				
E. Flowing (e.g. stream, river)	Often necessary: sedimentation/ filtration/ chlorination	Controlled access (see figure 9-2) Motorized pump to treatment and storage	As for B	Yield often varies seasonally
F. Standing (e.g. pond, lake)	Nearly always necessary: as for E	As for E	As for B	As for E

(1) An approximate ranking of sources by likely quality would be: rain (unlikely to be polluted), spring, borehole, deep well, shallow well, stream or river, lake, pond (very likely to be polluted).

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9-4 Characteristics of wells

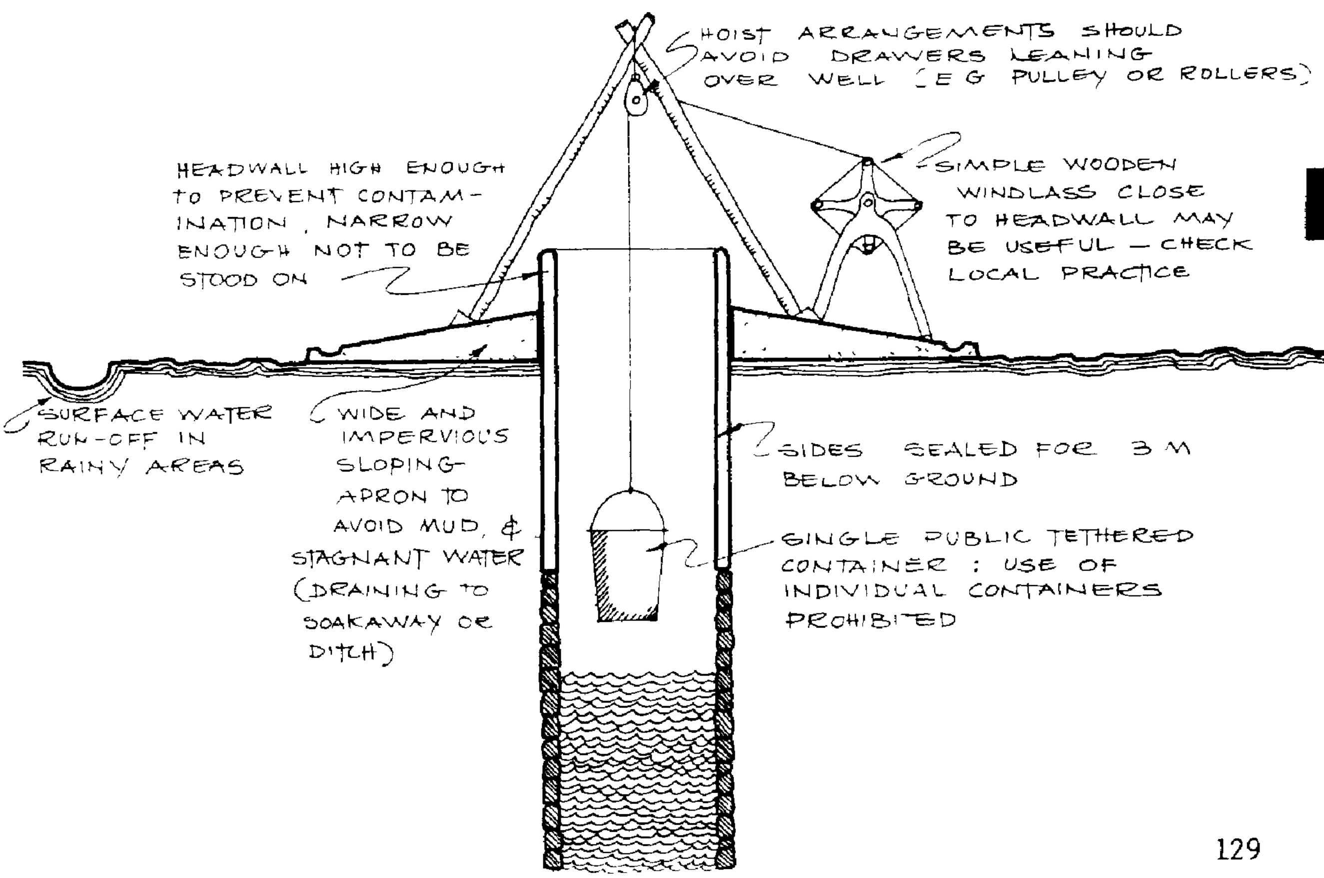
Type of well	Approximate maximum depth	Technique	Comments
Driven Tube well	10-15 metres	Simple: special pipe hammered into ground; can be sunk in 1 or 2 days	Small; cannot be sunk in heavy clay,soil or rock; needs special filter "well point" at tip of pipe
Bored Tube well	25 metres	Simple: handbored hole using an auger; can be sunk in 2-3 days	Larger than driven tube well; augers may need to be imported, but locally available boring tools can often be used
Hand Dug well	30-40 metres	Requires skilled workers otherwise dangerous. Speed depends on soil conditions. For team of 4 men perhaps up to week per 10 metres depth	Often the most appropriate solution, especially if the refugees traditionally dug such wells
Jetted Tube well	80 metres	More difficult: water pumped down a hole and over-flowing to carry out and loosen soil, enabling pipe to be pushed down	Requires considerable amount of water to sink, and special drilling equipment
Borehole	Over 100 metres	Large drilling rig	If more than some 50 metres deep,hand pumps cannot be used

8. The yield of a well depends on the geological formation in which it is sunk, the contours and gradients of the land, the well construction, and the pump. Any new well or borehole must first be "developed" to full yield by an initial period of pumping at a fast rate. This has the effect of pumping out finer soil particles and thus allowing water to pass more easily into the well. Yield can be raised by increasing the size of the well below the water-table, for example in the case of a shallow well, by an infiltration gallery across the line of ground water flow. If wells are sited too close together yields will be reduced.

9. Wells, boreholes and pumps should be disinfected immediately after construction, repair or installation, as they may have been polluted during the work. Two or three buckets of a 0.2% chlorine solution in water would be a suitable disinfectant and the techniques are described in the technical guides.

10. Like springs, wells must be protected from pollution. They should be located where surface water, and in particular any seasonal rain or flood water, will drain away from the well head. They should be above and at least 15, preferably 30 metres away from any sanitation facilities and their discharge. A well-head, consisting of a headwall and drainage apron, running off to a soakway, is essential to avoid direct contamination down the well. The headwall should not be so wide that people can stand on it. Rollers, pulleys or a windlass should be provided to avoid people leaning over the well. Individual buckets must never be allowed down the well, and close supervision and control will be essential. See figure 9-5. As numbers using an open well increase so does the risk of pollution and difficulty in raising sufficient water by bucket. It is then better to cover the well and use a pump.

9-5 PROTECTING AN OPEN WELL



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Rain water

11. Reasonably pure rain water can be collected from the roofs of buildings or tents if these are clean and suitable. This method can only be the major source of water in areas with adequate and reliable year-round rainfall, and it requires suitable shelter as well as individual household storage facilities. It is, therefore, not generally the solution in refugee emergencies. However, every effort should be made to collect rainwater and small collection systems, for example using local earthenware pots under individual roofs and gutters, should be encouraged. Allow the first rain after a long dry spell to run off, thus cleaning the catchment of dust etc. The supply of water which it is possible to collect by this method is estimated as follows:

One millimetre of yearly rainfall on one square metre of roof will give 0.8 litres per year, after allowing for evaporation. Thus, if the roof measures 5 x 8 metres and the average annual rainfall is 750 mm, the amount of rain water which can be collected in a year equals: 5 x 8 x 750 x 0.8 = 24,000 litres per year or an average of 66 litres per day (on many days there will be none).

12. Rain water may be a useful supplement to general needs, for example through special collection for the community services such as health and feeding centres, where the safety of the water is most important. It should also be noted that surface water is particularly likely to be contaminated in the rainy season. Thus rain water may be a useful source of safe water for individual use at a time when other water is plentiful but unsafe.

Sea water

13. Sea water can be used for almost everything but drinking, thus reducing fresh water requirements. In locations where no adequate sources of fresh water exist but where sea water is near, desalination is one possible but costly option. Neither of the two basic methods - distillation using the sun's heat or the use of modern desalination plants - is likely to meet immediate fresh water needs in a major emergency, so relocation of the refugees must be considered as a matter of urgency.

Municipal and private systems

14. Existing municipal and private water systems in the vicinity of the refugees, for example those belonging to industrial or agricultural establishments, may be able to meet part or all of the need during the emergency phase, and should obviously be utilized where possible before unnecessary measures to create other sources are taken. A substantial increase in the yield and quality of such systems may be possible if expert advice is taken.

9.6 Pumps, storage and distribution

- ☐ Mechanical pumps will often be needed. Seek expert local advice on what is suitable and remember the operators, fuel and spares.
- ☐ Water storage facilities will be essential.
- ☐ Distribution points should be within a few minutes' walk of the users' dwellings.
- ☐ Site the distribution points carefully and protect the ground around them.
- ☐ Standpipes and taps are usually best but vulnerable: one tap per 200-250 refugees.

1. Once an adequate source of water has been established, arrangements are necessary to store and distribute the water in a way that guarantees minimum

needs are met on a continuing and equitable basis.

2. In areas subject to seasonal flooding, or where the level of a river source varies markedly, great care must be taken in the siting of any pumps, distribution, storage and treatment systems. It may even be necessary to mount a pump on a raft.

3. Water can be raised in two basic ways: by hand using some kind of bucket or by using pumps. A captive rope and bucket carries a low pollution risk and is more reliable and much cheaper than any pump. Where this system can meet the demand it is to be preferred. The importance of preventing refugees putting their own containers directly into the source has already been stressed.

Pumps

4. However, in a major refugee emergency, pumps will generally be required, either to raise water for direct distribution at the well or to move it to storage tanks or other distribution points. All pumps have moving parts and require regular maintenance. Professional advice, particularly from locals, should be sought on the selection and siting of pumps. The basic hand pump can lift water some 50 metres (the piston is in a cylinder at the bottom of the well). Such positive displacement pumps use simple low technology and are relatively easy to install and maintain, and generally more reliable than motorized pumps. As an appropriate solution, which will minimise dependence on an outside supply of spare parts and fuel, the handpump is strongly to be preferred. Surrounding villages are likely to have handpumps. However, in a refugee emergency a sudden and large concentration of people requires that the output of available water sources be maximized. Motorized pumps have a far greater output and may therefore be indispensable. If motors are required, local advice should be sought. Local familiarity, fuel supplies, spares, ease of maintenance and above all reliability will be major considerations in pump selection. Self-priming centrifugal pumps are usually recommended when water has to be lifted a considerable height (up to 100 metres) or pumped over a long distance.

5. In some circumstances pumps powered by solar panels may be suitable. The present generation are expensive for their output but very reliable and involve no direct running costs. The next generation of solar pumps should be much cheaper. The pumps naturally work best in direct sunlight but will still work with light cloud cover. As a rough indication, a solar pump powered by panels rated at 250W would lift 1-2 litres/sec. through 6 metres on a sunny day. Thus a solar pump might be a solution when the output of a hand pump would be insufficient but large mechanized pumps are not necessary.

6. The theoretical capacity required of the pump depends on available storage as well as likely demand, as the demand will not be constant throughout a 24 or even 12 hour period. A reserve for breakdowns, new arrivals etc. should be provided. The minimum daily period during which a pump should be idle is that required to allow the level of water in the source to recover to its old level. Pumps should not be operated at night. Always have a standby pump on a major supply system to cover repairs and maintenance.

Storage

7. In nearly all systems it will be necessary to store water in covered tanks between the source and distribution points. This will provide an essential reserve, can greatly facilitate distribution, particularly when water is pumped up to elevated tanks, and helps purify water (see 9.7.4). Where sedimentation tanks are in use,

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their capacity alone should equal a day's consumption, thus allowing sedimentation to take place overnight. All refugee sites must be provided as soon as possible with facilities to store an adequate reserve of water. The size of the reserve will depend, beyond the number of people, on the nature of the water supply system in each case and particularly on its logistical aspects. Tank capacities are calculated as follows (use internal dimensions and overflow pipe heights):

(a) Rectangular tanks: length x breadth x height (in metres) x 1,000 = capacity in litres;

(b) Cylindrical tanks: height x radius^2 (in metres) x 3140 = capacity in litres.

8. In certain circumstances, notably in areas with pronounced dry and rainy seasons and where alternative sources of water are limited, the construction of a reservoir to collect water to be used during the dry season may be an option, despite the dangers of pollution and of mosquitoes breeding. An erosion-protected overflow spillway should always be provided. Catchment tanks for collection of surface water can also be considered in the drier parts of the world. Pits are dug in the ground to catch and hold the water which runs off hard ground during heavy storms. They need special lining in order to hold the water, and should be covered if possible.

9. Above-ground tanks may be needed where the water-table is very high and contamination cannot otherwise be avoided. A number of types of simple, air-portable, butyl rubber storage tanks are available and some can be supplied together with a complete distribution system. Headquarters' advice should be sought if local resources cannot meet this need.

Distribution

10. The refugees must have easy but controlled access to water. Ideally, no dwelling should be further than 100 metres or a few minutes' walk from a distribution point. Experience has shown that where persons have to fetch water from considerable distances, they tend either not to fetch enough to limit water-washed diseases or to collect water from closer but contaminated sources. Hence the importance of availability. Water distribution will be an important consideration in the layout of the site. The distribution points should not be in hollows. The area round the point should be paved with stones or gravel, or protected by boards, with a run-off to allow proper drainage.

11. Water can be distributed to individual users in a number of ways, depending on local conditions. Uncontrolled access by individual consumers to primary water sources must be avoided. A distribution system should have a sufficient number of sources and/ or outlets in relation to the size of the population to ensure that people do not need to wait for long periods to have access. Equity in the distribution of scarce water is an extremely important consideration. While vulnerable groups (the sick, wounded, most severely malnourished, children, pregnant and lactating women and the disabled) should have adequate and assured allocations, scarce water must be evenly shared among the rest of the population. Refugees should be encouraged to assume responsibility for equitable distribution, and arrangements carefully monitored in order to detect and prevent abuses. In some situations, water meters have proved a cheap and efective way of identifying excessive users and reducing their consumption.

12. The most appropriate method of distributing water to large populations will depend on a number of variables in each specific

situation, such as the kind, number and location of primary sources and the availability of materials, equipment and expertise. Between source/storage and distribution point, water for domestic use should flow only in pipes in order to protect its quality. These must be watertight: leaking pipes will suck in pollution when the pressure drops or the system is turned off. Pipes may be made of plastic, metal, cement or bamboo. Bamboo is unlikely to be suitable in the majority of emergencies and polythene pipes are often the cheapest and easiest to lay. Polythene piping is available in lengths of coiled, flexible pipe as well as in the form of rigid lengths, commonly of 3m. Pipes should be buried for protection and sections of the system should have isolating valves.

13. As outlets, standpipes and push taps are recommended where possible. Taps are, however, very vulnerable and spares must be available. Where water supplies are limited and the site is crowded, valve distribution points which can be chained shut may be the only effective solution. There should be one tap per 200-250 refugees. The larger the number of people using a single source or outlet of water, the greater the risk of pollution and damage. Whatever the final distribution system, this must be carefully controlled and supervised; watchmen are often needed.

14. A certain amount of waste water will be generated in the community, both at the individual and communal service level. This must not be allowed to become a danger to public health, but it may be usefully recycled, for example to water livestock, irrigate vegetable gardens or in flush latrines.

9.7 Treatment

- All methods of water treatment require some expertise, regular attention, and maintenance.

- The most serious threat to the safety of a water supply is contamination by faeces.

- Covered storage is the simplest method of improving water quality.

- Sand filtration is an effective method of water treatment.

- Chemical disinfection for large-scale water treatment is generally only recommended if storage and/or sand filtration cannot meet the need.

- Water purification tablets and boiling are not generally appropriate for large-scale water treatment.

The dangers

1. The water may contain pathogens, particularly certain viruses, bacteria, protozoal cysts and worm eggs which are transmitted from faeces to mouth. Water contamination by human faeces is the major concern, although animal faeces in water may also cause disease transmission. Water contamination by urine is a significant threat only in areas where urinary schistosomiasis (Schistosoma haematobium) is endemic. By far the greatest risk associated with polluted drinking water is the spread of diarrhoeas, dysentries and infectious hepatitis (hepatitis A). The diarrhoeas and dysenteries are caused by a variety of viruses, bacteria and protozoa. The numbers of viruses and protozoa in water will always decrease with time and will decrease most rapidly at warm temperatures. Bacteria behave similarly, but in exceptional circumstances may multiply in polluted water. The infectious dose of the viruses and protozoa is typically very low, whereas the dose of bacteria needed to establish an infection in the intestine may be large.

Treatment

2. The importance of trying to find a source that does not require treatment has been stressed. If treatment is necessary, it should be the minimum required to ensure acceptably safe water, using appropriate technology and a method that is reliable. Determining how to treat water on a large scale is best done by experts, and if possible professional engineering advice should be sought. However, simple and practical measures can be taken before such help is available. Full explanations of types of treatment are given in the technical guides; the main systems are summarized below. All methods require regular attention and maintenance.

3. In addition to the physical measures to protect water at its source and initial disinfection of wells and boreholes (usually by chlorine), there are four basic methods of treatment: storage, filtration, chemical disinfection, and boiling. These can be used singly or in combination.

4. Leaving water undisturbed in containers, tanks or reservoirs improves its quality. Storage causes some pathogens to die off and any heavy matter in suspension to settle (sedimentation). In an emergency where water supplies cannot be assumed to be safe, immediate action to provide maximum water storage capacity is a logical first step. Storage of untreated surface water for 12 to 24 hours will already bring about a considerable improvement in its quality; the longer the period of storage and the higher the temperature, the greater the improvement. The clarification of cloudy water can be greatly speeded up by the addition of aluminium sulphate. A two tank system is often used, the first tank being a settling tank with the second storing the clarified water. If treatment is required this can be done in the second tank, and a third used for storage if necessary. While clear water may only require chlorination, turbid surface water will usually require sedimentation and/or filtration before chemical disinfection; even so greater doses of chlorine may be required.

5. Great care should be taken to prevent pollution of stored water. Storage tanks must always be covered: the dangers of contamination of open tanks more than offset the advantages of direct sunlight. The storage area should be fenced off, and if necessary guarded, to prevent children playing or swimming in the water.

6. Longer storage can help control schistosomiasis (bilharzia), as the parasites die if they do not reach the fresh water snail within 24 hours of excretion by an infected person, or a human or animal host within 48 hours of leaving infected snails. Thus two days' storage would provide an effective barrier to transmission of the disease, provided snails do not enter the tank.

7. Sand filtration can be an effective method of treatment. A proper slow sand filter works in two ways. Passage of the water through the sand physically filters out solids and, more important, a thin and very active layer of algae, plankton, bacteria and other forms of life develops on the surface of the sand bed. This is called the "schmutzdecke", where micro-organisms break down organic matter. The rate of filtration depends on the surface area, depth and type of sand through which the water is passed, and the head of water. The usual size range of the sand is 0.3 - 1mm. Provided the rate of filtration is slow enough, the quality of the treated water is very good.

8. The types of sand filters are described in the technical guides. A packed drum filter can be improvised if drums and sand are available and may be a good way of providing limited quantities of safer water quickly, for example for a

health centre. The water passes down through sand on a 5cm. layer of gravel and is drawn off at a rate that should not exceed 60 litres per hour for a 200 litre drum. If a tap is used, unfiltered water equal to the amount drawn off is simply added to the top. Other types of sand filters include the horizontal sand filter and the river bed filter (suitable only where the bed is permeable). These can be used to treat larger amounts of water but are likely to be more difficult to set up quickly and effectively. For a river source a possible intermediate measure is to dig a well close to the bank. The water recovered will be river water but will have been filtered through the bed and bank.

9. Chemical disinfection as a method of water treatment on a large scale is, as a rule, recommended only in situations where storage and/or filtration cannot meet the need. It will, however, be required initially to purify wells, sand filters, pumps and piped water systems. Both iodine and various forms of chlorine can be used; chlorine is more widely used, cheaper and often more readily available. The most generally suitable form of chlorine for refugee emergencies is calcium hypochlorite powder. Methods of chlorination are described in the technical guides. Expert advice is essential for large-scale chlorination. All systems require regular attention and will be of little value if not fully reliable. Chlorination should take place after any sedimentation or filtration process. It requires at least thirty minutes to act.

10. Care must be taken to ensure strict control of any chemical disinfection process and particularly to test the water for chemical residual levels after each disinfection and before distribution. After chlorination there should still be at least 0.2 parts of "free active chlorine" per million in the water, in other words, still available to kill bacteria. The amount of chlorine required to achieve this is usually a broad indication of the level of pollution. If the amount of "free active chlorine" is much above 0.5 parts per million, people may not be prepared to drink the water: over-chlorinated water tastes unpleasant and will have the reverse of the desired effect if people therefore prefer untreated water. Chlorine and iodine water purification tablets are also available, but are rarely suitable as a method of water treatment for large populations. They may be used in health or supplementary feeding centres.

11. Boiling is the surest method of water sterilization, and at low altitudes simply bringing water to the boil will destroy all pathogens that may be transmitted by drinking water. Boiling should, however, be continued for one minute for every 1,000 metres of altitude above sea level, as the boiling temperature reduces with altitude. Prolonged vigorous boiling is often recommended but is not necessary to destroy the faecal-orally transmitted pathogens; it is wasteful of fuel and will increase the concentration of nitrates in the water. Water with a high concentration of nitrates is dangerous for very young babies. Domestic fuel supplies may in the longer term be the determining factor; boiling requires about 1kg of wood per litre of water. However, if the refugees have traditionally boiled their water and can continue to do so, this should be encouraged and, at least initially, may make the need for other types of treatment less urgent.

Further references (1)

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Howard J. (1979)	Safe Drinking Water Information on treatment methods	Oxfam Technical Guide
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(1) See also the further references at the end of chapters 7 and 10, only some of which are repeated here.