5. Water: General Principles

5.1 Quantity and quality considerations

The general objectives of emergency water supply can be simply stated as:

IMMEDIATE
To protect water sources in order to minimise the risk of contamination.

To provide good quantities of water of a reasonable quality.

MEDIUM-TERM
To improve the physical and biological quality of the water.

To improve access to supplies through improved distribution networks and storage facilities.

These objectives are not mutually exclusive and work can be done on them simultaneously. Good practice must dictate that all work is carried out within the context of a safe working environment. All precautions must be taken to ensure the safety of people working on a construction programme. The emergency does not mean that normal safe working practices can be ignored.

Water is used or 'consumed' by a population for drinking, cooking and hygiene purposes. As a general rule, the more water people can be encouraged to use for personal consumption the better. An absolute minimum of 3 litres/person/day is required for drinking and as an overall minimum 7-8 litres/person/day should be provided[5]. However, it is worth noting that if people come from an area where water has been scarce or difficult to access, it is possible that their daily consumption will be less than expected, as was the case in Rwanda where per capita daily water consumption in camps all over the country in 1993/4 averaged out at 7.5-8 litres/day. Although aiming to increase the amount of water

[5] Mears and Chowdury (1994) in Annex 1.

available and consumed, the agency responsible for the provision of water should pay special attention to the volume actually being used. If water is being brought by tanker the cost per litre will be very high, and a balance should therefore be aimed at between water available and water consumed, supported by the option to increase water availability in the camp should demand increase.

It is always desirable to have sufficient storage capacity inside a camp to meet at least one full day's demand, and this should be increased as far as funding allows. This is particularly important in the case of a water tankering operation where there are no other sources of water available. The fragile nature of a tankering operation means that often insufficient water will reach the camp. Stored reserves are crucial in such circumstances, and every effort should be made to stockpile water in the camp and to keep the stock as high as storage facilities permit. In this way, during periods of poor water delivery, volumes available to the camp population can be maintained. Where it is known that delivery of water is going to be problematic, the camp population should always be kept informed.

Difficulties will always arise in an emergency when deciding what is a reasonable or acceptable quality for water. It should be remembered that the WHO guidelines outlined in Annex 3 are in fact guidelines and, as such, desirable standards to be achieved. The overriding principle with regard to water quality must be to improve the biological and physical quality as much as possible with the means available, and to reduce the opportunity for disease transmission.

Biological and physical indicators can be easily monitored using simple analysis methods and kits. Portable kits specifically designed for this purpose are available. Reliable and relatively inexpensive water test kits, such as the Delagua, which was developed jointly by the Roebens Institute at the University of Surrey, UK, and OXFAM specifically for use in emergencies, will cost from $1,500, and are widely used.

A more contentious aspect is that of who has responsibility for water quality monitoring. Regular monitoring is very important. Frequently it is the agency providing the water which, for its own reasons, takes on the responsibility for reporting on its quality; this can be acceptable to other agencies when there are no problems, but if outbreaks of water-related diseases occur it will cause considerable friction. It is preferable that a third party should have responsibility for monitoring, recording and reporting on biological quality concerns. Local water departments may have this capacity; failing that, another agency with no direct interest in health service provision for the emergency, should be used.

Existing protected sources (piped systems) or groundwater sources (springs and wells) are likely to provide water of a better quality than surface sources (rivers, lakes).

5.2 Options for providing/increasing water supply

Broadly these fall into four types of approach:

- transporting water from existing sources to the population via piped systems or tankering;
- increasing the output/quality of existing sources by increasing pump and piping capacity, borehole/well deepening or treating surface water sources;
- creating new sources by drilling new boreholes or digging new wells;
- siting/resiting the population nearer to a better source.

Transporting water from existing sources to the population

Tankering. This is a costly and potentially fragile system. The preferred option is to move to a more sustainable supply system as soon as possible. Tankering performance can be impaired by problems related to: access in rainy seasons; poorly maintained vehicles frequently breaking down; driver management problems – selling water can be a lucrative form of income in arid areas and drivers paid a daily rate have no incentive to make as many trips as they can; and independence of supply, e.g. regular access to the draw-off point may be limited if this is a town supply. From its origins in 1988 Hartisheik camp in Eastern Ethiopia, which at the height of the emergency accommodated 273,000 Somali refugees, experienced many such problems (See Box 6).

Box 6

Hartisheik

Water was brought to the camp from the nearest reliable source, which was the town of Jijiga, 75km away along very poor roads. When it rained, the clay soils in the camp made it impossible for the tankers to get close enough to the water storage facilities to unload; there were continuous difficulties related to managing the drivers ; because of the poor roads and unsuitability of the type of tankers used, vehicle breakdowns were frequent. Clearly the site was inappropriate from a water point of view, an issue that was recognised at the outset of the emergency. However, political constraints prohibited the movement of the camp population to more appropriate sites. The only option available for developing a water source closer to the camp was at a valley approximately 35km from the camp. Drawing water from this site released a great deal of tanker capacity as fewer vehicles could carry the same amount of water to the camp.

Continued reliance on tankers illustrates the difficulties faced when it comes to obtaining funding for developments after the main emergency has died down. From the earliest stages of the valley site development, there had been plans to pipe the water to the camp but has proved difficult to find the necessary funds and an agency willing to undertake such a large infrastructural project.

Piping/pumping. Introducing a piped or pumped water system into an emergency will mean injecting a level of technology which will require design, management and maintenance. This dictates a level of technical knowledge and understanding on the part of the agency providing the water supply. In designing a technical system, making use of locally available equipment and levels of technology should be a priority. The quantities of materials locally available at the outset of the emergency may well be insufficient and relief materials will need to be imported. But the move to use local materials should be made as soon as possible; this will go some way both to ensuring the sustainability of the system and that local levels of expertise can be readily employed.

Pumping is expensive. Pumping water over large vertical or linear distances is very expensive and specialist equipment and technical knowledge are essential. Agencies involved in providing water in emergencies tend to stock, as standard response kits, pumps that are rated to a maximum of 40m. Allowing for the physics of pumping water, this effectively means a maximum height of 30m. If the decision is made to take water to the affected population, specialist equipment will therefore need to be ordered, with the inevitable time delays. As the height and distance increase, so will the water pressure, and the need for specialist engineering skills rises correspondingly.

Maintenance of pumps (diesel or electric) and generators (for electric pumps such as submersible pumps used in boreholes) tends to breakdown; motors burn out; control panels for electrical switching burn out or fail; powerlines come down and spare parts run out. A planned and adequately resourced programme of maintenance for all of these components is essential. Standby capacity for pumps and generators is needed. Pumps and generators are often imported and spare parts are not available in the country; stocks of regularly used as well as major spare parts are essential. Any generator or pump sent anywhere in the world by OXFAM will be accompanied by a spares package for 6,000 running hours. This goes some way to minimising the risk of extended breakdown due to mechanical failure. Again, good technical advice is a worthwhile investment when specifying equipment; it is very common for agencies to purchase the wrong equipment.

Increasing the output/quality of existing sources

Well-deepening. To make wells deeper, it is necessary to keep the bottom of the well dry to allow people to work there. 'Dewatering' can be done by hand with buckets, handpumps, etc., or by using mechanical dewatering devices, which usually allow work to proceed faster and to a greater depth. However, it is unlikely that a village that is responsible for the maintenance of its own wells will have a dewatering pump available to it. This means that if anything goes wrong with the well in the future, it is possible that they will not be able to correct it.

If wells need to be deepened, the distribution of tools may be a more appropriate response than the provision of a dewatering pump, thus allowing the villagers to carry out their own improvements in a more appropriate and sustainable manner. In this instance, the agency involved in the programme has a responsibility to ensure quality control and to work with the villagers on the safety aspects of hand-dug wells.

If hand pumps are to be used on shallow wells, there is a responsibility to ensure that a good level of training is given to the maintenance technicians. This must be supported by adequate spare parts and technical back-up.

Springs. If there are springs in the area the problem may be one not of quantity available but of access to the water at peak demand periods early in the morning and late in the afternoon. One way of dealing with this is to provide an enclosed reservoir to catch the night-time flow which would otherwise have been wasted. From this a number of distribution points can be provided, thus enabling more people to collect water at the same time than at the previous single spring point.

Two aspects need to be considered when relying on spring sources: first their reliability as a water source, and secondly the quality of the water. Before investing a lot of time and effort into developing a spring source, the agency should be reasonably confident that the spring will continue to flow at an acceptable rate. Local information about the spring is therefore invaluable. If the spring is first identified during the dry season and is flowing well, there is a strong possibility that, with the advent of the rains, its yield will improve. The converse is true if it is identified during the rainy season. Having said this, springs can be very unpredictable and alternative sources should be kept in mind.

As with water from a borehole, unless there is a major source of contamination, spring water which is filtered as it passes through the ground, is likely to be of high quality. This has the direct benefit of eliminating the need for treatment to improve the quality. This gives rise to the question of chlorination, and whether a supply of good quality water requires the addition of chemical disinfectants.

The short answer to this is yes. The supply source may well be of good quality, as is usually the case with spring water; however, the containers used for its transport, and the handling the water receives after collection, can seriously contaminate it. In this instance, the objective of chlorination is to provide a residual of active chemical in the water which can go some way to disinfecting the way it is handled after collection. The agency providing the water can have control over its quality only up to the distribution point; thereafter it is the responsibility of the users. There is a direct relationship between hygiene practices and water-washed or water-borne diseases. It is at this point that the hardware component of a water supply system gives way to software interventions. The engineers have a responsibility to ensure that the agreed chlorine residual is present at the collection point and this is the point at which residual levels should be measured. Annex 7 discusses the chlorination process in more detail.

Using existing pipelines. When they were originally installed, piped water systems will have been designed to benefit the maximum number of people. It is probable, therefore, that there will be very little scope for increasing the numbers of people that can draw water from them. If large numbers of additional people start to take water from existing pipe systems, there can be serious impacts on the populations downstream. This needs to be taken into account when dealing with any network. There is one other drawback to relying on such piped systems. People, like water, always take the line of least resistance. If an agency relies upon piped water systems or explores ways of marginally increasing the water available through them it is possible that this may inadvertently have a negative impact on the water and sanitation related diseases in the camp, by encouraging people to wait for inadequate quantities of water at or nearer the camp rather than tapping large volume sources, such as springs, some distance away.

Treatment. From the outset it is worth stating that there is no definitive method for treating water. Every water source will display differing characteristics and there will be a number of ways of treating them. The important thing in supplying a refugee camp is to get reasonably clean large quantities of water flowing to the camp. After this, the quality can be improved and there will be the opportunity to try alternative methods of treatment with a view to simplifying the process.

The objective of any treatment system is to bring the water to an acceptable level of clarity so that the chemical used to disinfect it can be as effective as possible. The overall aim of the process is to kill all pathogens in the water and thus minimise the risk of transmitting disease through the water supply. Particulate matter can encourage the growth of bacteria and protect pathogens against the effects of disinfection. The simple chlorination of cloudy (turbid) water, for example, will require more chlorine than clear water and, even then, the water may still not be safe to drink. Water treatment, therefore, aims first to remove the pathogens and particulate matter by mechanical and biological means (settlement, filtration, etc.) before relatively clear water can be finally treated by disinfection.

It is probable that there will be a great deal of suspended solids, i.e. particles of soil, in the water. Individually, these particles are likely to take a very long time to settle. If the process of settling can be speeded up, then it should be possible to produce large quantities of clean water within acceptable time limits.

A standard form of water treatment uses the system of sedimentation and flocculation to settle the solids. This process can be speeded up with the addition of certain chemicals. In emergencies, the most frequently used is aluminium sulphate, usually referred to as alum.

Used either as an independent treatment or as part of the sedimentation and flocculation process, rapid pre-filtration (often referred to as roughing filtration) can significantly reduce the turbidity of water. One or more stages of roughing filtration before flocculation can significantly reduce the time needed to treat a batch of water and hence the equipment needed for the water programme.

Another system of water filtration is known as Slow Sand Filtration (SSF). This has the significant advantage of being able to purify and filter water if it is designed and managed well, and can be a very effective means of supplying good quality drinking water. However, by definition SSF is a relatively slow form of water treatment, and volumes of water for large numbers of people require a large-scale installation. If a displaced population is in excess of 15-20,000, SSF will not be able to supply sufficient quantities of water without a very significant capital investment.

It is always worth experimenting with ways to reduce the amount of treatment required. For example, digging wells by the side of a river or lake may offer a good means of initial physical and biological filtration. If water flows freely into the wells it may be possible to supply the camp with this ground-filtered source of water. One well is unlikely to supply sufficient quantities, but drawing water from a number of wells may prove satisfactory. The riverside well is sometimes referred to as an infiltration gallery, as water passes or infiltrates from the river or lake.

Another form of infiltration gallery can draw water from under a river or stream. This is technically complex as the river will need to be temporarily diverted whilst pipes and layered gravel are placed below the river bed. Once this has been done, the river can once again follow its natural course and water will filter through the gravel and into the pipes which run out into a collection gallery which will have been dug into the river bank. This method was used successfully in East Sudan in 1986 to serve 100,000 refugees in the Wad Kowli and Sefawa camps. The infiltration galleries were constructed across the River Atbara during the dry season and saved what would have been a great deal of expense and effort in chemically treating highly turbid river water.

Creating new sources

Boreholes. Groundwater is naturally filtered and, as such, its bacteriological quality is likely to be good. This has an immediate benefit for emergency water supply as it means that little or no treatment will be required before distribution to the population. It is possible however that the water is chemically unacceptable for human consumption. Problems are frequently encountered with the level of salts in groundwater which makes the water unpalatable. In most instances, very little can be done to remedy this.

Another common occurrence is to find high levels of iron and manganese in the water, which make it unpalatable. This can be dealt with relatively easily by employing very simple aeration techniques in the system.

As with all emergency water supply systems, attempts should be made to maximise the storage capacity. Supply from boreholes can be erratic as they are dependent upon mechanical devices for bringing the water to the surface, and at some stage will inevitably break down.

Box 7

An interesting situation arose in 1993 in Northern Afghanistan in the programme for refugees from Tajikistan. A camp was being established in desert conditions. It was known that there was a layer of water 20-30m below ground level. This would make it a very appropriate depth for hand-dug wells as a medium-term solution to the water problem. However, the water turned out to be highly saline, and so the major source for the camp continued to be the borehole supply which was drawing water from a non-saline layer at 60m.

Such considerations emphasise the fact, that when water is being drawn from a deep groundwater source, the level of technology employed is high, and is usually much higher than that commonly used in the area. This has considerable implications for the continuity of supply, as it is imperative that adequate spare parts, technical knowledge and funding are available to run the system.

In the simplest form, if the groundwater is less than 50m below the surface, it may be possible to consider drilling small-diameter boreholes (sometimes referred to as tubewells) which can be fitted with a hand-pump to lift the water to the surface where it can be collected for use. Where the geology and soils of an area allow, it is possible to drill such wells by hand. This is a very common practice in countries such as Bangladesh, India and Nepal. The volumes of water that can be delivered via hand-pumps are relatively small; accordingly the only way to produce sufficient water for a sizeable population is to install many handpumps. This is a time-consuming process and is unlikely to form part of the immediate emergency response.

If hand drilling is not feasible, it will be necessary to use a drilling rig. If this is being considered, a useful starting point is to find out as much as possible about the likelihood of finding sufficient quantities of water where the drilling is to take place. Water-bearing strata below ground level are called aquifers. Information about them is most likely to be found in water departments or universities, but any agency that has been involved in water development will possess such hydrogeological information. From these data, it should be possible to estimate whether or not sufficient water can be produced to support the population. Having said that, there are no guarantees that water will be found where it is needed or that the quantities will be adequate. Drilling for water is a risky business and frequently many attempts have to be made to find it.

Knowing how deep the water is and how much piping will be used, is important when ordering pumps and ancillary equipment such as generators. An accurate estimate of the volume of water required for the population will provide an indication of the number of boreholes needed and dictate the capacity of the pump(s). It is always best to allow for increased demand when specifying this sort of equipment, to avoid the need for re-ordering larger equipment. The distance the pump has to push the water will determine the size of its motor and the power of the generator required to supply the electricity.

Informed technical advice concerning drilling rigs and boreholes can pay for itself many times over, if correct solutions are prescribed at the outset. In an emergency, it is possible that cheap, lightweight drilling rigs will be more than adequate for the job. However, those who are to be involved in taking decisions about funding or embarking on a borehole programme ought to be aware of the technical complexity of such a programme.

Where the agency is not drilling the boreholes itself, it is important that a drilling contract should be drawn up covering all eventualities. For example, who pays for the unsuccessful holes? What happens if the contractor has to abandon the well? The UNHCR *Water Manual for Refugee Situations* provides guidelines for its implementing partners regarding technical specifications for well construction (see Annex 1).

Operating a borehole-sourced supply system implies ongoing technical support. As outlined under the *Piping and Pumping* section above, managed maintenance will be necessary.

Borehole yields can reduce with time. This can be the result of the initial drilling and development process or can be associated with the chemical composition of the water and the type of materials used in the borehole. Consequently, the yield should be monitored regularly so that problems can be identified early in their evolution and remedial measures adopted.

Rainwater harvesting. Although very useful at a domestic level, rainwater harvesting is unlikely to be able to supply the needs of large numbers of people. Rainfall is erratic and unreliable. It is not therefore recommended as an emergency water supply source. However, rainwater catchment from large roofed buildings, such as medical centres, can provide a useful supplementary source for feeding centres and clinics.