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## water supply as a world problem

'In engineering, as in the other arts, simplicity is the ultimate virtue'.

*attributed to James Watt, 1736-1819.*

'An engineer is a man who can carry out successfully, for fifty cents, something that any damfool can do for a dollar'.

*attributed to Herbert Clark Hoover, 1874-1964.*

### INTRODUCTION

From time to time the United Nations and the Specialised Agencies (the World Health Organization in particular) make assessments of the water supply situation on a world-wide scale and put forward proposals for improving the undoubtedly serious conditions existing in many countries. The latest proposal of this nature is contained in the United Nations Second Development Decade (1971-1980) programme.

The starting point (the situation as it existed in 1970) was based on an analysis made by WHO of figures supplied by its member countries throughout the world, and targets were set for achievement by 1980. Briefly, it was proposed that a determined effort should be made to increase (during the decade) the percentage of urban dwellers supplied with piped water into their houses or courtyards from 25% to 40%, of townspeople receiving water from public standpipes from 26% to 60%, and of rural inhabitants supplied with safe water from less than 10% to at least 20%. To achieve these objectives in those countries that were members of the United Nations at that time (i.e. to cover rather more than three quarters of the world's population) would be expected to cost 9.1 thousand million U.S. dollars; one sixth of this sum would be required for rural improvements, and the remainder for urban projects.

Provided that the margins of error inherent in global estimates of this nature are recognised these figures (and their breakdown under regional headings) can give us a useful overall picture of the situation - indeed

from no other source can a similar world-wide appraisal be obtained. There are dangers, however, in placing too much reliance upon their accuracy then and now, and it is even more fallacious to draw the conclusion that the water supply problems of the world are solely those of finance, capable of being neatly solved by the allocation of funds to the totals estimated.

To start with it must be obvious that although the figures, produced six or seven years ago, were obtained from the best possible sources (i.e. from the countries themselves) considerable extrapolation was involved. Assuming that such statistics as rural and urban populations, numbers of communities already adequately served with water, and so on were reliably known (and this does not necessarily apply in every country) forecasts of population growth and urban migration had to be applied to these figures to reach the estimated situation at the end of the decade in 1980. Similarly, financial estimates were based on per caput construction costs, and however accurate the figures on which these estimates were based extrapolation to cover similar projects in other countries - even within the same country - inevitably weakened their reliability. Again, such unknown factors as inflation and rising costs over a ten year period must have added, and will continue to add, substantially but unpredictably to the overall estimates.

With these reservations we have the world problem stated in a simplified form - to provide a basic piped water supply service to urban dwellers and safe water sources to serve one fifth of the rural population in the countries under consideration called for 9100 million U.S. dollars, an estimate that has almost certainly increased since it was formulated six years ago. Without denigrating the massive aid given by international and bilateral agencies or the substantial efforts made by many of the countries concerned it seems unlikely that funds on this scale will be made available for water supply within the period, however desirable we may consider this objective in comparison with the innumerable other claims that compete for whatever funds can be allocated.

In any case, under present circumstances, it is safe to say that even if money on this scale were immediately forthcoming it would not lead to the prompt and complete solution of the problem everywhere. In many developing countries lack of finance is only one of many restraints. Institutional, legislative, administrative and organizational inadequacies, lack of trained and experienced personnel, the absence of a national plan based upon basic knowledge of the situation within the country, would all have to be remedied before a constructional programme on the scale required could be embarked upon.

A further fallacy that oversimplification in the statement of present positions and future objectives may conceal lies in the confusion between the construction of facilities and the provision of water to the consumer. It is only too easy to accept the logic that because a water pumping station, treatment works and distribution system have been installed in a certain town it necessarily follows that all the inhabitants of that town will continue to receive an ample, safe and continuous supply of domestic water indefinitely. The existence of a number of expensive installations, now wholly or partly idle or operating inefficiently, in various parts of the world bears witness that water supply problems do not cease when construction is completed, and that the setting up of a management organization to finance, operate, maintain and extend as necessary is as essential as is the initial provision of pumping plant and other physical components.

In other words the objective to be aimed at is not merely the construction of facilities but the continuing and continuous supply of ample quantities of water of suitable quality in a convenient manner to every individual at a price which he can afford. (We may even extend this definition to encompass the raising of the health, social and economic standards of

consumers through the provision of such a supply). Many disciplines, as well as those of the water engineer, contribute to this end, and there is a danger that in concentrating upon our own particular sector we may ignore or underestimate the viewpoint and the problems of the others concerned. The very attempt to define water supply as a world 'problem' (in the dictionary sense of 'a question propounded for solution') can blind us to the complexity of the whole subject and lead us to believe that there is such a thing as a single, simple, universal 'solution' waiting to be discovered.

The following somewhat disjointed notes, written by an engineer from an engineering viewpoint, are intended to call attention to some of the aspects of water supply generally, especially in the developing countries, that have to be recognised and reconciled if our full objective is to be approached. Some of these are our own direct concern, others may lie outside our immediate responsibility, but we cannot afford to ignore the influence that they may have on the success of our work. The comments made under each heading represent solely the opinions of the author, and are submitted as a basis for discussion rather than as incontrovertible principles.

1. a) Water Supply as a consumer problem

The most important person having anything to do with any water supply anywhere in the world is the individual consumer. He it is who suffers from the effects of deficiencies in the quality, quantity and availability of the water that he receives; he it is also who eventually has, directly or indirectly to pay the costs of providing an improved supply. The installation is intended for his benefit, and upon the care and intelligence with which he uses it will materially depend the length of life and efficient working of many of its component parts. It is surprising, therefore, that it is only rarely that he is consulted on the proposed installation, offered a choice of services to be provided, informed as to its potential benefits, or taught how to make the best use of it after completion. This is in spite of the fact that all concerned - planners, designers, health officials, engineers, politicians - are themselves, as individuals, water consumers and might be presumed to have personal first-hand knowledge of consumers' problems.

It must be remembered that everyone on earth has a water supply of some kind, otherwise life would be impossible. It may be dangerously polluted, insufficient in quantity, inconvenient in situation, seasonally unreliable, or all of these, but there is enough for his minimum needs or he would not be living where he is. Only in comparatively few instances is an installation intended to produce water where none existed before; the more normal function is to purify, store, pump and distribute water that already exists at or near to the community to be served. If the consumer takes a dislike to his new supply for any reason, for example because it is too expensive, or because the water tastes excessively of chlorine, he has the ultimate sanction available. He returns to his old, dangerous source and the new supply has failed of its purpose.

So far as is possible a new installation should always be a response to a felt, preferably an expressed, need. Consumers will be much more likely to take care of, and to pay (sometimes even cheerfully) for, something that they have themselves requested rather than something that has been provided unasked by some distant authority. To those politicians, professional men and others who are well aware of the economic, social and health implications of a good water supply it sometimes comes as a surprise to find that the criteria of potential consumers are not necessarily the same as their own. The medical officer may condemn an existing source as a bacterial or parasitic hazard; the consumer is

probably unaware of the invisible dangers to his health and far more concerned about the distance he (or, rather, his wife) has to walk daily to satisfy domestic needs, or about the colour of laundry washed in iron-rich water. In such cases a preliminary campaign of education in the connection between disease and water quality may make all the difference in the attitude of the people to be benefited. If they can thus be persuaded to demand improved quality and safety the new installation is off to a good start.

A further point that should be discussed with and accepted by the consumers concerns the standard of service to be provided. Certain features of any new installation should not be negotiable - e.g. the maintenance of safe quality and of continuity of supply - and the reasons for this should be made quite clear to all concerned. With this reservation there are a number of variables that can make a great difference to the amount that the consumer will have to pay, both for capital and recurrent expenditure. It is obviously preferable, for example, that water should be piped into homes or compounds rather than delivered through communal standpipes or watering points, but equally obviously someone has to pay for the increased initial expense. The decision as to whether the additional cost is warranted ought to be made by those upon whom the burden will fall. Certain physical aspects of the delivered water, such as colour, odour, seasonal turbidity, excessive hardness or iron content, may be considered as nuisances rather than as hazards. They can be remedied - at a price. The consumers should be informed as to the options open and the comparative cost implications. Consultation on such matters can make all the difference in the acceptability of the installation by the consumers.

#### b) Water Supply as a community problem

Because the quality and reliability of domestic water (a very small proportion of which is actually ingested) are of such importance to health, improvements in these aspects usually constitute the principal reasons for constructing new installations. From the community point of view there are also numerous non-domestic uses to be considered, in developing countries as well as in industrialised ones, which may have a bearing on the social and economic well-being of the consumers as a group.

These uses, and the potential benefits, will largely depend upon local circumstances. In a highly developed society such tangible benefits as improved land values, reduced insurance premiums, increase in property valuation, the ability to wash cars or to water lawns may be attributable to a good municipal water supply. A tropical agricultural community are likely to be more interested in watering domestic livestock or irrigating small vegetable plots. Even in rural areas there may be a potential for industry dependent upon an ample water supply - e.g. cotton ginning, textile dyeing, pottery, fibre retting - while a variety of commercial users and tradesmen, such as bakers, blacksmiths, brick makers, slaughtermen, fish curers or tanners can benefit by a readily accessible supply. Obviously in the bigger communities such uses increase in number and diversity.

Then there are municipal and communal uses that must be taken into account. A modern city uses water for street cleansing, an agricultural village to wash down market stalls. Without a piped supply hospitals and clinics cannot operate properly, schools cannot be made hygienic, waterborne sanitation cannot be considered and adequate fire protection is impossible. Buildings, whether of modern reinforced concrete or of primitive mud bricks, require considerable quantities of water in their construction, and this use is frequently forgotten. Hotels, public bathhouses and laundries, food preparation establishments (including soft drinks manufacture) are examples of other non-domestic purposes for which water is essential.



Because the absence of water is a limiting factor for uses such as these they are likely to be absent in water-short communities. When a communal supply is to be installed or extended it is therefore a fallacy to base its design upon existing demands, even if these are extrapolated to satisfy an increasing population. Representatives of the community itself are likely to be best able to forecast the changes that the installation will produce in individual and public demand, and then only if adequate information is provided as to the potentialities that will be opened up, and of the way in which other similar communities have developed in comparable circumstances.

With this information before them the community representatives should be encouraged to share the decision as to the extent to which future needs should be catered for in the initial construction. Designers, consulting engineers and planners are often criticised for shortsightedness on the one hand (when an installation proves inadequate and has to be extended after a short time) or for extravagance on the other (when the full capacity of a new system is not immediately taken up). Weighty arguments can be produced for both pessimistic and optimistic estimating; the immediate (and almost universal) shortage of funds and high rates of interest on capital will call for initial economies and minimum designed capacities, while the high cost of enlargement or duplication later and the reducing value of money will suggest providing an ample capacity margin from the start. The skill and foresight of the designer will help him to steer a middle course between these extremes, but involvement of representatives of the community itself in the decision (after presentation of the full facts) is not only a wise precaution but is also elementary justice, since it is they that will have to live with the system (and pay for it) for many years to come.

It is also important that community representatives should know precisely what the new installation will entail, both in terms of annual costs (capital repayment and recurrent expenses) and of other non-financial obligations. In many countries it is the practice to hand over a completed installation to the local authority to manage and maintain even though construction may have been financed and carried out by the central government or other agency. This often has many advantages, including the encouragement of civic pride of ownership, but it adds to local responsibilities and there are numerous instances where the municipal (or other local) authority has been insufficiently prepared to meet these responsibilities. Operating, managerial and supervisory staff must be engaged and trained before taking up their duties; fiscal arrangements must be made if water rates are to be collected; health authorities must be prepared to exercise quality control of the water supplied; byelaws or other legal provision for the ownership, protection and proper use of the facilities should be arranged in advance; budgetary provision may be necessary for the regular purchase of fuel, chemicals and other materials as well as for the payment of operating staff; arrangements must be made for maintenance, renewals and future extensions of the system, and so on. It is also highly desirable that some form of public information service, applicable to the size and character of the community, is worked out so that the understanding and co-operation of its individual members can be assured on a continuing basis.

In short, just as individual consumers should be consulted as to their domestic requirements so the local authorities, as representatives of the consumers as a body, should be involved in the preparation and planning of the installation as a whole, so that they know exactly what will be required of them before they accept the custody and care of the works that will be of common benefit.

c) Water Supply as a national problem

The degree to which Governments are directly engaged in the planning, construction and management of water supplies varies from country to country according to the political system and other factors. Organizational patterns include autonomous water corporations; central departments within the Ministry of Health, Public Works, Municipal Affairs or other appropriate Ministry; devolution to State or Regional Governments; devolution to municipal authorities; or combinations among these. In general each system represents a compromise, best suited to national conditions, between two opposing considerations.

The arguments in favour of maximum delegation of authority include the desirability of involving the consumers to the greatest possible extent in decisions affecting their welfare; the encouragement of civic pride by local ownership and management of local installations. Those in favour of a centralised organization include the economies made possible by standardisation of designs, techniques and equipment; setting of priorities on a national scale, allocating to the best advantage scarce funds, materials and manpower; overcoming the shortage of skilled personnel that may prevent efficient supervision and operation of smaller undertakings.

In developing countries especially there are certain functions that can best (or only) be performed at national level. Some of these are the following -

Construction capital. While large cities and prosperous communities may be able to raise this from local resources, or through such means as bond issues, lotteries or bank loans, the majority of projects require assistance in the form of loans, grants or guarantees. In those countries receiving international or bilateral financial aid the donor agencies invariably require Government backing for any request. Whether national or external sources of funds are utilised the Government is inevitably involved, and this implies at least a measure of national control over the work to be carried out.

Definition of the problem. Planning and programming must start with an assessment of the problem on a national scale, an estimate of the resources required to satisfy all demands compared with the resources actually available, and a setting of priorities to make the most practicable use of the latter. This calls for action at national (possibly, in some countries, at state or regional) level.

Basic data. Among the essential tools of the planner are demographical, geological, meteorological, hydrological, topographical and other statistics, together with information on a diversity of subjects, such as anticipated future development trends, prospects of tourism, industrialisation or mineral development, planning in other sectors (e.g. air, sea or road transport proposals), all of which may affect the future of individual communities and their respective water supply needs. Usually such data can only be collected and compiled on a national basis.

Water resources exploration and development. Except possibly in the case of very large projects the cost of geological or geophysical exploration and of deep drilling for a single water supply is prohibitive, and could not be undertaken by a local authority unless there happened to be private companies operating in the area. The more usual arrangement is for a government department to undertake work of this type (either directly or by means of a multiple contract) on a countrywide basis, co-ordinating the programme of exploration and development to the priorities of water supply construction.

Standards and standardisation. A degree of standardisation (as will be discussed later) in design, in equipment, in construction techniques, in standards of service and in other factors can result in considerable

economies; only a central authority, such as a government department, can provide the necessary guidance to enable local authorities to reap the benefits thereof. Further economies can result from bulk purchase and from interchangeability of spares, equipment and materials between neighbouring supplies, and a co-ordinating authority is necessary to ensure that such procedures are encouraged and facilitated wherever possible.

Recruitment and training of personnel. The attractions of water engineering as a profession are greatly enhanced when there is a unified staff structure with promotion prospects for the best men. Few local authorities will be of such a size as to warrant a professional staff large enough to offer this inducement; many will be unable to afford or obtain properly qualified officers. Similar comments apply to other senior personnel, e.g. chemists, bacteriologists, geologists, managers, and also (to a lesser extent) to sub-professionals such as draughtsmen, surveying staff, supervisors and the like. Even when there are prospects of mobility from one undertaking to another it is necessary to have nationally acceptable standards of qualification and experience, and this involves provision of training facilities that are usually only feasible on a countrywide scale.

Laboratory services. Again, few undertakings will be large enough to provide and operate laboratories solely for water quality surveillance, and although pooling of services and the use of university and hospital facilities may be the appropriate solution in many instances this usually calls for co-ordination by a central authority.

Other functions. A number of other functions, including research and development, evaluation (both engineering and health), materials testing, encouragement and standardisation of local manufacture, specialist maintenance (e.g. instrument calibration and repair), holding of emergency stocks to deal with disasters, are all more suitably undertaken centrally. In addition there are legal functions, such as water legislation, plumbing regulations and codes of practice, that must be co-ordinated throughout a country.

Irrespective of how or by what agency a national programme is implemented, the important thing is that there should be a countrywide plan, fully supported and encouraged by the central government. The problems of supplying safe water to the vast numbers of people still in need are so large, complex and diversified that only concerted effort can hope to solve them. The first step is to initiate such a programme and to identify clearly the department or person responsible for its promotion. Experience has shown, in those countries where major and widespread improvements in the situation have been accomplished, that the success has been largely due to an expressed government determination translated into action by vigorous departmental action.

Latin America provides a number of recent examples of this; under the charter of Punta del Este each signatory government set itself a target and then designated who was to be accountable for ensuring that the target would be achieved within a stated period. Momentum was maintained by the proviso that progress reports, comparing objectives with actual achievements, should be produced and made public annually. Inter-country rivalry may have played some part, but there is good evidence to show that the rate of progress achieved by this method has outstripped results recorded from other parts of the world during the same period. While it is not suggested that any one pattern of programme can be of universal application it would seem that a study of those that have been shown to be successful should provide valuable guidance in other countries where it is hoped to achieve similar (or better) results.

d) Water Supply as an international problem.

Assistance to developing countries for water supply construction has been forthcoming from international agencies, and from other countries through bilateral agreements, at a steadily increasing rate over the last couple of decades. The provision of good water is a particularly attractive channel into which such assistance may be directed; it is essentially peaceful in character, has beneficial effects on the health, social and economic well-being of the people, is part of the infrastructure that makes other improvements possible, and is generally and genuinely welcomed by the recipients.

It seems very probable that international and bilateral aid could and would be extended considerably if more countries had the initiative and the available technical expertise to prepare and submit soundly based and economically justifiable proposals. Money is usually available for well conceived projects, and often, when lack of external finance is quoted as a reason for non-implementation, the real cause may be a failure to present a (financially or economically) attractive proposal.

International and bilateral agencies provide assistance of several kinds, but there is one consideration that often weighs heavily with them. They prefer to deal with large projects or with programmes incorporating a number of smaller projects rather than to be concerned with numerous small and unconnected proposals.

Hence while water supplies for large cities may be acceptable (though even with these it is often found preferable to combine water supply proposals with other related improvements such as sewerage and sewage disposal, storm drainage and the like) the chance of obtaining approval for rural or small urban projects is considerably enhanced if they are combined together into a national programme. An alternative, less often adopted, is to include a community water supply project in, say, an integrated health improvement programme, and by combining the installation with other construction (e.g. hospital, clinics) to bring the total proposals to a size that would warrant consideration as a single application.

Of the international agencies the one most concerned with providing technical assistance in water supply matters is the World Health Organization (WHO). Acting on the premise that a safe and reliable water supply is a pre-requisite for a healthy existence WHO provides advice and assistance to its member countries in a number of ways, probably the most important of which is the allocation of staff members to work within the countries, training local counterparts and assisting in the initiation and implementation of national programmes. Such field staff operate from regional offices, the policy of each being directed by the countries of the region concerned. Other functions of regional offices and headquarters include the preparation of manuals, guidelines, standards and other documentation in languages appropriate to the recipient countries, the collection and dissemination of basic data to facilitate planning, and the co-ordination (through an International Reference Centre) of research and development activities in countries in many parts of the world. WHO is not a financing organization, in that it does not provide loans or grants for construction activities, but through its field and office staffs it advises and assists governments to obtain financial assistance from other international and bilateral agencies.

Of such agencies the World Bank is the most active in granting loans for water supplies. They lend to governments, at reasonable rates of interest, the cost of construction of facilities, in which they include such expenses as surveys, designs and other preparatory costs. However, any application for a loan must be supported by a considerable amount of background information relating not only to the technical aspects of the proposed project itself (including arrangements intended for its future management and operation), but also to economic and financial conditions within the



country and to details as to how the investment is to be protected and loan repayments in the future are to be guaranteed.

To obtain and present this information in the required form often calls for pre-investment studies, including feasibility reports, management studies and other preparatory investigations, and these are frequently beyond the capacity of the available professional and technical staffs in developing countries. Recognising this difficulty the United Nations, through its Development Programme Special Fund, makes grants to enable governments to engage international firms of consulting engineers to carry out the required pre-investment studies. WHO assists in preparing terms of reference for such firms, in the selection procedure, and in providing guidance and co-ordination during the course of the surveys, acting (for this purpose) as representatives of the United Nations.

Other international agencies provide different types of assistance. The United Nations Children's Fund (UNICEF) have been active in supporting rural water supplies in many countries by supplying imported materials and equipment (to countries where a lack of hard currency would preclude the use of foreign exchange for the purpose) and by training of local technical personnel. The Food and Agricultural Organization (FAO) sometimes gives similar assistance to agricultural communities.

Various industrialised countries provide assistance for water supply projects under bilateral agreements. Each has its own set of conditions, and in some cases pre-investment studies are required; WHO assists (if so requested by the recipient government) in similar ways to those applicable to internationally supported projects. Bilateral assistance may take the form of loans, grants, extended credits, the provision of professional and technical staff, training of local personnel, or other arrangement. Assistance may also be forthcoming from particular institutions in donor countries, e.g. from universities, famine relief organizations, charitable and non-profit-making organizations, research institutions and the like.

In general all forms of external assistance have two conditions in common: donor countries or agencies work through recipient governments rather than deal directly with municipalities or other local authorities within countries, and they prefer to act within a co-ordinated national plan rather than to assist particular projects in isolation.

## 2. a) Water Supply as a health problem

Sufficient documentation already exists to make it unnecessary to describe here the connection between such 'waterborne' diseases as typhoid, cholera, dysenteries and impure domestic water supplies. Almost equally well known and accepted is the reducing effect that a pure and ample supply has upon the incidence of so-called 'diseases of dirt', including scabies, ringworm, trachoma, tropical ulcers and the like. Certain parasitic diseases (e.g. dracontiasis) and viral infections (e.g. infectious hepatitis) are known to be contracted through drinking unsafe water. Various estimates have been made of the percentage of mortality and morbidity from these various diseases in developing countries particularly, but no statistics are necessary to envisage the human misery, infantile (and adult) deaths, crippling and blindness that are transmitted in this way. Such other health improvement programmes as those for improving nutrition may be partly or wholly vitiated if the food ingested merely goes to feed water-carried intestinal parasites. Cost-benefit studies of improved water supplies may be useful in persuading economists of the advantages of this service, but we do not have to await the result of such studies to know that suffering and premature death can be prevented if waterborne and water related diseases can be eliminated or reduced.

It is often pointed out that a water supply is not the only vehicle by which such infections are carried, and that other works of environmental improvement, such as food hygiene, sanitary disposal of excreta and garbage, control of flies and rodents are also called for if health standards are to be raised. This is true, but is no argument for neglecting water supplies; indeed the presence of ample quantities of safe water may contribute to and facilitate these other sanitary measures. Ideally, raising of environmental standards in any community would call for a co-ordinated programme of improvement in all these aspects, and wherever possible this should be the approach. However, when only limited resources (of money, manpower and effort) are available there are good reasons why water supply improvement should be regarded as the first priority. Experience has, in any case, shown that other forms of sanitary improvement are more likely to follow water supply installation than vice-versa.

Another argument sometimes used when water supply expenditure is under consideration is that increasing the quantity of domestic water available may create health problems that did not exist before. A particular example is filariasis, the vector of which may breed in undrained pools of sullage water. Again there may be some validity in the argument, but it is an indictment of the designer of a system who failed to anticipate the need to dispose of waste or surplus water rather than of the principle of installing improvements. Similar reasoning applies when a muddy area around an insufficiently drained standpipe becomes the focus of a hookworm outbreak.

The need to identify and anticipate such hazards, to be able to assess health situations calling for improvement, to maintain surveillance and quality control of completed installations, to educate the public in hygienic aspects of water use, to evaluate the public health effects of proposed and completed improvements, calls for participation of the health authorities, and for a close liaison between the medical and other professions involved in planning, design, construction and subsequent management. The smaller the installation the more valuable is this co-operation likely to be, since a small community is unlikely to be able to call upon the expertise, experience and back-up services (e.g. chemical and bacteriological analysts and laboratories) that might be afforded by a large city undertaking. In the case of small scattered rural improvements the medical and sanitary staff of the health authority provide, in a number of countries, the only inspection and surveillance of village installations. Even if these latter consist solely of source improvements such as sanitary wells, hand pumps, spring catchments or rainwater collecting areas they need occasional surveillance, otherwise the very works that were installed to benefit the villagers may act as foci of disease transmission.

Apart from these considerations the health authorities can be very valuable allies to engineers and others engaged upon water supply improvement. By stimulating demand, initiating planning, justifying expenditure with supporting health statistics, pressing for quality standards, guiding public opinion, identifying health hazards of an endemic or local nature, and in many other ways they can complement the efforts of other professions. Health problems usually constitute the principal motivation for water supply improvement (and for the allocation of funds for this purpose); it is only logical that health authorities should be closely associated with every stage leading to solutions of these problems.

b) Water Supply as a finance problem.

There is a great deal of truth in the generalisation that large urban water supplies can be made self-supporting financially by wise management, but that rural and small urban undertakings can never be viable without subsidies or other assistance from a central authority.

There comes a point, however, when a country's water supply coverage has extended to include the majority of the population, and when this point is reached all consumers will be paying their own subsidies directly or indirectly. Although this fortunate position has, as yet, been reached by few developing countries any national programmes that lead to complete coverage must take the eventual possibility into account.

There is an almost universal (and somewhat natural) reluctance to paying for water as such; the argument that it is a 'free gift of God' can only be countered by an explanation that what is charged for is not the water itself but its extraction, treatment and conveyance to the point of consumption. This is part of the public relations message and is best delivered before the installation of a new supply and the arrival of the first bills. At that time consumers should be made aware of what their liabilities will be in the future; where water rates are to be collected separately the wording of the demand can continue the message. Properly presented the cost of a supply can be shown to be a bargain, and can be favourably compared with the charges for electricity (which are usually accepted without undue question) or with the cost of private water carriers.

Even when community supplies are subsidised from central sources there is a great deal to be said for the consumers bearing at least a portion of the cost, either individually or through community taxes. It is also highly desirable for separate accounting to be done for each supply, showing clearly the proportion attributable to capital repayments, operating and other recurrent costs, and the degree to which the total is subsidised. A simple accounting system, incorporating easily understood forms for annual returns, applicable throughout the country, is well worth inauguration; it permits easy comparison between similar undertakings, is helpful to local authorities, and is informative to consumers themselves who should be encouraged to take an interest in the efficiency of their own systems.

Almost certainly some assistance in the form of loans, revolving funds or other devices will be necessary for most supplies requiring capital expenditure on a scale beyond the community's capacity to finance from its own reserves. Repayments will be needed over a period of some years (with or without interest according to government's financial policy). It is often useful to continue collection at a similar rate after loan repayment is completed in order to build up a reserve fund for replacements and extensions, thus avoiding having to take out another loan when such expenditure later becomes necessary.

Methods of collecting the cost of delivered water vary widely according to policy and custom, and broadly fall into three categories - payment for the amount of water received, payment of an individual rate, or inclusion of water charges in other communal taxes. Each has its advantages and drawbacks, so that none can be said to be universally applicable, even within a single country. Payment by quantity received penalises the poorer consumers and those with large families; it also has the additional disadvantage that when other, unsafe sources become available during the rainy season consumers may make use of these to save money and thus throw away the health benefits that the supply was designed to provide. On the other hand it is often felt that this is the fairest way of distributing the cost - each paying in proportion to what he uses. From a practical point of view it is usually the most expensive method, calling for metering of individual connections or for attendance and collection of cash at public watering points.

Individual rates, whether levied on a per caput basis or graded according to the value of a dwelling, may be less fair to the careful consumer but are more practical and easier to collect, especially if this is done by an existing rate-collection organization within the community. Disadvantages are that waste is less easy to control, and that it is difficult to charge for casual use by non-ratepayers.

Incorporation of water charges into community taxation is probably the simplest method, but it may help to conceal inefficiency and does not conduce toward a viable self-financing undertaking. Personal involvement of the consumers and their sense of joint ownership is reduced, and there is less inducement to reduce waste and use the installation carefully.

Whatever system is adopted there must be adequate budgetary provision for the forward purchasing of fuel, treatment chemicals and other recurrent expenditure, including wages. It is dangerous to separate income from expenditure in such a way that necessary purchases are delayed until funds are made available from other communal sources, or until rates have been collected.

### c) Water Supply as a maintenance problem

It may appear illogical to consider the subject of maintenance before those of design and construction, but the maintenance facilities should have an important bearing on the type of equipment installed. It should be an absolute rule that nothing should be included in any system that is beyond the capacity of the local people to operate, and for which there are no facilities for service and repair easily accessible.

If a designer wishes to include, for example, submersible electric pumps, electrode controls or individual house metering for the first time in a country he must ensure that there are personnel trained to service these items properly and also workshop facilities to enable them to do this. There must also be advance arrangements to permit them to undertake work of this nature for others. If, for instance, there is an adequate water meter calibration department in a large city undertaking this may have the capacity to serve the needs of smaller neighbouring supplies that do not have such facilities, but prior agreement of both authorities is necessary before it can be said that adequate servicing arrangements have been made.

In the absence of adequate servicing facilities the planner has two options open - to have the design changed so that simpler equipment is called for (even though this may involve a nominal reduction in efficiency) or to include within his project the provision of the appropriate maintenance facilities.

Another subject worthy of special mention under this heading is that of mechanical well drilling equipment. A common fallacy that has proved extremely expensive to many governments is that the provision of drilling rigs automatically ensures unlimited water everywhere. Apart from the questions of personnel and of hydrogeological investigation (referred to later) it is no exaggeration to say that a drilling programme depends upon, and is as good as, its maintenance and servicing facilities. Even when rigs have been furnished free from external sources they can prove a liability rather than an asset if there is no mechanical and skilled staff to keep them operating efficiently. Furthermore, the service requirements of different types of rig (percussion, rotary, hammer-down-the-hole) are so different that the addition of another type should always be preceded by special training and the acquisition of appropriate spares, repair tools and workshop facilities.

Construction equipment (e.g. concrete mixers, portable shuttering - even hand tools) and transport require regular inspection and maintenance. Their use also calls for careful planning if the best advantage is to be made of them; faulty logistics is one of the easiest ways to boost construction costs even on labour intensive projects.

On piped water supplies one of the most neglected items of maintenance is the distribution itself; actual studies of existing systems that have been in operation for some years have revealed losses, in some cases

exceeding 30% of the distributed water. Mains leakage constitutes not only a major operational expense but also a considerable health hazard when negative pressures draw polluted surface water into the system through breakages and faulty joints. Proper design with this in mind, adequate training and equipping of waste control teams, and a carefully worked out programme of inspection and regular checking can do much to minimise these losses. On large distribution systems the initial outlay can almost always be justified.

d) Water Supply as a source problem

It is obvious that a primary requirement for any water supply is an ample source of raw water suitable for processing and delivery to consumers. It has been the experience of the author that in the majority of cases this condition presents fewer technical problems than at first appears. Difficulties, when they arise, are more often those of economics; the most suitable sources (from the point of view of quality and quantity) being sometimes at a distance, or capable of development only at a relatively high cost.

One reason for this is that existing communities have usually been founded and have grown up near to a water source. Many major cities are sited on river banks, smaller settlements make use of streams, springs or wells, but all have some form of supply or they would not be where they are. (There are exceptions, of course, such as communities serving oil refineries, mineral development or military posts, but these are special cases outside the scope of these general notes). The usual problem of the planner is therefore to increase the quantity or improve the quality of an already available source. Only when this is impracticable does the question of finding and developing completely new sources arise.

A perennial subject of discussion is whether quality or quantity of the raw water should be the more important criterion. Treatment to improve the former is usually more easily and cheaply installed than additional works to augment the latter, but the greater the reliance on treatment to make unsafe water potable the greater the danger of human error putting the entire body of consumers at risk. It is suggested that the prime consideration should be reliability and potential for expansion.

In a number of documented accounts of waterborne epidemics it has been shown that the public water supply, built many years previously, was not the vehicle of infection, but that inadequate and intermittent service drove many to drink water from other, unsafe, sources. This is most evident in cities around which large overcrowded slums or 'squatter towns' have established themselves - a development not anticipated by the original designers of the municipal water supply, but one that must today be regarded as an ever-present possibility, given a continuance of the present trend of urban migration in developing countries.

Much has been written about the competition among different types of usage for scarce water resources, e.g. the conflicting claims of hydro-power, agricultural, industrial and other agencies for sources that may be required for community supplies, but such conflict is not very common in practice. Except for the largest cities the quantities extracted are comparatively small, and where there is an adequate system of sewerage and sewage disposal treatment a substantial proportion is returned to the watercourses, even though this may be degraded in quality.

A common difficulty experienced by designers of water supplies is the lack of basic data on the resources available - hydrogeological and hydrological information concerning ground and surface waters respectively. Collection of this data cannot be done quickly - vital information such as stream gauging and groundwater table fluctuations have to be continued for at least a year to have any significance, preferably they should cover



several years. In most cases the water supply project is urgent and the engineer is under pressure to go ahead with design based upon inadequate data. Occasionally this results in failure (e.g. a dam that does not fill, a stream intake that dries up in a period of drought, an overdrawn aquifer that ceases to produce because of insufficient recharge), but more commonly the designer 'plays safe', thus producing a project that does not take full advantage of the resource potentialities and hence is more expensive than necessary.

The additional costs so incurred are not obvious (except to the designer himself) and so cannot be compared with the cost of undertaking investigations in advance, but there seems little doubt that when a country has a programme of water supply development extending over a period of years it is worth while initiating a systematic hydrological survey well in advance of design and construction. It will usually be too much to expect that all potential sites can be covered in this manner, but basic investigations in sample areas representative of typical conditions can be most valuable. Such investigations might include stream gaugings related to catchment areas, meteorological records, rates of evaporation and run-off; draw down and recovery rates of typical aquifers during test pumping; seasonal fluctuation of spring discharges and of the chemical composition of ground waters; dates and levels of river flooding.

Ground water exploration is a subject upon which there is much misconception in many countries. The myth persists that geophysical equipment is the answer to all problems, there being a choice of mysterious 'black boxes' that enable an unskilled operator in unknown country to locate water, oil, coal and mineral resources, and to obtain accurate information on their depth, abundance and chemical composition. There is, unfortunately, no such substitute for the skill and experience of the geologist, though suitable geophysical equipment may be most useful in extending the range and accuracy of his investigations. A long term programme of geological surveys, backed by samples and records from well sinking and drilling operations, is the most (probably the only) effective method of predicting ground water occurrence. The earlier such a programme is set up the more accurate the picture that emerges; this is especially true when a widespread rural water development programme is under contemplation.

With regard to ground water extraction another common fallacy is that mechanically drilled boreholes are necessarily better than hand dug wells under all circumstances. This is by no means always the case, and hand digging should not be despised as outdated, particularly for supplies to smaller rural communities. There are, of course, a number of geological formations that cannot be effectively penetrated by hand methods, but in general there are probably more people in the world being supplied from hand dug wells today than from any other form of ground water extraction. A hand dug well programme is cheaper than mechanical drilling, requires simpler equipment and less imported materials, makes use of relatively unskilled operatives, calls for less supervision and back-up services. In favourable conditions it may actually produce more water. On the other hand individual wells take longer to construct, and the method is more suited to sinking in sedimentary formations and weathered strata than in hard granites or similar bedrocks.

Drilling can rarely be carried out efficiently on a single rig basis, and is best organized as a programme operating with grouped rigs in one or more areas. Maintenance facilities are vitally important (as has been mentioned earlier) and transport must be continually available to service the drilling teams with fuel, water, fishing tools, casing, and to move rigs from one drilling site to another. Ancillary craftsmen (e.g. blacksmiths for tool dressing) must be at hand. When a single project (e.g. a city supply) calls for exploration and construction holes it is usually worth considering bringing in experienced drilling contractors unless there is already a strong drilling department with proved expertise in the type of borehole required.

e) Water Supply as a rural problem

There are almost as many definitions of 'rural' (as distinct from 'urban') water supplies as there are countries; for the purpose of these notes 'rural' installations will be taken to mean supplies for those villages and other communities that are not large enough to have a local organization capable of constructing and managing works on their own. Hence planning, design, construction, operation and management are the responsibility of a regional or other 'group' authority, and the supply itself is one item within such a group.

From the engineer's point of view the difference in approach between urban and rural projects is greater than would at first appear. The multiple nature of rural projects calls for special techniques, and it is a misconception to think that these small supplies are merely 'scaled-down' versions of urban installations, calling for less engineering skill and ingenuity. The exact opposite may often be the case.

In those countries that have made good progress in their water supply programmes, particularly in the countries of Latin America, it is noticeable that priority has almost invariably been given to urban projects, with the result that such communities are now much better served than are the rural ones, even though the latter may represent the major proportion of the country's population. There are a number of reasons for this, including the greater political pressure that can be brought by larger communities, the increased hazards of epidemics when large numbers of people depend on a single water source, the fact that townspeople are usually more able (and more prepared) to pay for an improved supply. Perhaps equally significant is the fact that comparable effort on the part of the design and construction staff can produce greater and more immediate results in terms of the number of people served when dealing with compact communities; also that those same staffs are often reluctant to travel into remote 'bush', with the attendant problems of transport and accommodation. The natural tendency is to concentrate, where possible, on the jobs nearest at hand. In addition there is usually more professional satisfaction in successfully completing a few 'tailor-made' 'showpiece' projects than a large number of less interesting repetitive schemes.

Yet it is in such repetitive work that considerable ingenuity is required if maximum results are to be obtainable with inadequate funds, a shortage of skilled and supervisory staff, and with special difficulties of communications and logistics. Of these restraints staff shortage is often the most serious, and it is not too much to say that this factor alone would be enough to make the provision of rural supplies on the scale required impossible in many countries if reliance were placed solely upon conventional procedures.

The first bottleneck is at the investigation stage, where ideally a topographic survey with levels should be carried out as a preliminary to producing a design, estimate, list of materials, specification of pumps and similar preparatory details for each project. For large schemes, and for certain of the more difficult small ones, these preliminaries are essential, but there are very many cases where the requirements can be relaxed if adequate precautions are taken. Given specific training an assistant can produce, during one visit to a village, a sketch based on pacing and a hand-held level sufficiently accurate to enable an experienced engineer at headquarters to judge whether a detailed survey may be dispensed with. If his decision is that there are no complications calling for a further visit the sketch is passed to a designer and estimator to select standard items of equipment and standard design details suitable for the project.

To do this involves some loss of efficiency - for instance a limited number of pump types and sizes must be available, each having broad characteristics that will permit their use over a wide range of heads; a

few sizes of mains piping must be decided upon and selected from even if some oversizing is inevitable; type plans of a few stock sizes of reservoirs, tanks, watering points should be available, of which the quantities and costs are known from experience. A simple multipage form can be worked out, of which the surveying assistant (or sanitarian) completes part in the field. This would consist of basic demographic figures, notes of special demands such as schools, clinics or commercial premises, together with his sketch and proposed siting for intake, storage tank, pumphouse, standpipes. Upon receipt in headquarters the design engineer decides whether the project is sufficiently straightforward, or whether he himself should visit. If the former, he selects his standardised equipment and type designs and passes the form to the estimator, who prices the construction work, estimates running and other costs (for the information, inter alia, of the local authority) and the document in due course goes (when permission to proceed with the job is obtained) to the storekeeper to issue the necessary materials and equipment from his central store. Thus a single form constitutes the record and history of the project from initial inspection to completion.

Construction procedures can also be simplified by standardisation and the use of type designs, but special preparation and training may be necessary. It is possible to make use of semi-skilled, often illiterate, men to carry out repetitive work of some complexity; a trained team of local masons, for instance, may be able to construct a particular size and type of storage tank without even being able to read a measuring tape, let alone a plan.

Nowhere is this more evident than in the task of well sinking. Once the techniques have been worked out and the teams have completed a few wells under close instruction and supervision they can often be entrusted to repeat the same techniques, unsupervised, in remote locations. Experience has shown the precise quantities of materials required for a specific task, and also the length of time it will take. Adopting these techniques a single foreman can supervise work on a number of sites where traditionally a skilled man should be in charge of each.

The above methods presuppose a prior knowledge of local conditions, and also of the intended water sources. There are bound to be areas where this knowledge is lacking and investigations (with consequent delays) are inevitable, but in tropical countries especially there are usually large areas over which similar conditions pertain, and engineering judgement is needed to identify where this can be relied upon.

#### f) Water Supply as a design problem

Owing to the nature and number of the variables encountered in water supply design there can never be a 'cook-book' giving instant solutions to all problems.

Large projects particularly repay careful and accurate design. In a city supply a small percentage variation in the efficiency of a pump or in the rate of flow through a filter may represent an appreciable increase or decrease in construction or in operating costs; sound engineering practice demands that each stage be examined for alternative possibilities, and that, after comparison, the most economic (not necessarily the cheapest) of those found feasible should be incorporated into the final design. Such supplies are considered in isolation as 'one-off' projects, and each must have its own provision for stand-by plant, emergency breakdown and regular maintenance spares.

Obviously one of the variables to be considered is the speed with which replacement equipment can be obtained and installed, and the inland city in a developing country remote from the place of manufacture will have to carry a much higher proportion of unused capacity (in the shape of spares and stand-by equipment) than those that can get replacements within days or hours after a telephone call to the suppliers.

In the case of smaller urban supplies this 'factor of safety' provision becomes more onerous. When a number of projects are planned they tend to fall into groups of similar (though not identical) design - e.g. those utilizing river intakes, boreholes, or impounding reservoirs as sources. Savings in capital outlay can be made by standardising equipment and holding replacement stocks within the country so that they are more readily available when required. This leads to simpler and more repetitive design, with less burden on design staffs, though some loss in efficiency may result. A careful appraisal of these opposing factors will be necessary. However, the advantages of standardising on a limited number of equipment items are not limited to the original design and construction stages.

Slow running reciprocating pumps (for use both above and below ground), belt driven by one of a small range of engines or motors, may not be as efficient as high speed turbine or electrosubmersible pumps. For larger schemes one of the latter will probably be specified; for numerous smaller supplies the former, with their flexible performance and adaptable characteristics, may be much more suited to a country's requirements. Maintenance is greatly simplified, reconditioned pumps and engines can be held and quickly substituted in the event of a breakdown, thus reducing the need for standby boreholes, intakes, pipework as well as the plant itself. Mechanics and fitters can become thoroughly conversant with a few types of equipment, pipework and bases can be of a pattern to permit interchange, and so on.

By adhering to a particular material and standard for the more usual sizes of distribution mains, a common pattern of joint, and as few different specials as possible throughout the country, training of mainlayers will be greatly simplified, stocks of spares may be reduced, neighbouring undertakings can help each other in an emergency, and the prospects of human error are reduced.

One external difficulty that may have to be overcome if the full benefits of plant standardisation are to be fully realised is the budgetary policy in many countries, whereby the requirements for each project have to be the subject of separate competitive tender. The advantages of large bulk orders covering a number of years should be stressed. Apart from obtaining better prices for such large orders manufacturers can often offer better service, such as holding quantities of spares at their own expense within the country, and will usually help in training maintenance staff by receiving them into their own factories for a period.

Apart from mechanical equipment and imported materials there are a number of in situ construction details that can with advantage be standardised throughout a country. There is little merit in the individual design of pump bases, filter shells, storage tanks, even valve and hydrant boxes, when similar items have been already constructed elsewhere in the country. A series of designs of such details in a range of sizes, with accompanying quantities, lists of materials, and estimates, available centrally and used wherever applicable, can be a very valuable investment in time and effort. It is also sometimes possible to use these as a basis for prefabrication of such components as reservoir roof slabs, caisson rings, meter boxes and covers, and other items that ingenuity may suggest.

Design must always take into consideration the limitations of available materials, expertise and constructional equipment. Since in most developing countries unemployment is an ever-present problem, the more labour intensive construction methods will be welcomed, and design should make provision for these. At the same time foreign exchange is usually scarce and the maximum use of locally produced materials is to be encouraged. Thus when designing, say, a reservoir dividing wall the use of reinforced concrete poured into steel shuttering, mechanically vibrated and incorporating a concrete waterproofing agent may be the correct and obvious choice in a country where reinforcing steel, mechanical plant and

skilled operatives for reinforcement setting are available. In a developing country there may be advantages in hand placing and ramming of mass concrete between two skins of masonry or brickwork to serve the same purpose. At first sight this may seem retrograde and old fashioned; young local engineers anxious to gain a reputation for modern thinking will certainly condemn such a suggestion. Yet if the simpler (cruder, if you like) method is what the economy of the country demands it is the better design.

Similar considerations will determine the choice of treatment and other stages to be incorporated by the designer. It could be that local conditions make it essential to instal rapid gravity rather than slow sand filters - the inexcusable design fault is not to have considered all aspects of the two alternatives before deciding upon one or the other. To specify boreholes (mechanical plant; imported fuel and casing) where hand dug wells (labour intensive; some reinforcement the only imported item) would produce the same or better results could only be justified if the pros and cons of each had been carefully weighed.

#### g) Water Supply as a legal problem

In a number of countries experience has shown that the construction and management of water supplies have been hampered by the lack of, or the out of date nature of, appropriate legislation, including byelaws, codes of practice, plumbing regulations and the like. Although this subject may seem out of place in notes written by an engineer, it is worth placing on record a few instances where legal questions may hinder the engineer's functions.

Ownership of water sources. In many countries the ownership of natural waters (ground and surface) is vested in government and presents no problem. There are other places in which a complicated system of traditional water rights persist, adding greatly to costs and to delays in getting work started.

Ownership of land. Suitable sites for intakes, pumping and treatment works or reservoirs may be privately owned, and again involve time and expense in their acquisition. Difficulties may also arise in obtaining wayleaves for transmission mains and the like.

Ownership of completed installations. When a new water supply is to be handed over to a local authority or other body on completion, the procedure and the responsibilities accompanying the new ownership should be clearly defined in advance.

Right of entry. Cases are not uncommon where staff (e.g. geologists, surveyors) have been prevented from entering upon private land to make preliminary investigations.

Supply of information. Much valuable information regarding aquifers and other sub-surface conditions may be in private hands e.g. mineral or oil exploration companies. To prevent duplication of effort it is often useful to have legislation insisting that records of all deep excavations (including well sinking and drilling) be deposited with the government geologists.

Quality surveillance of water. The respective duties and functions of health and of water agencies in testing and maintaining the quality of raw and delivered waters should be defined. It may be considered that nationally accepted quality standards may also be of assistance in carrying out surveillance.

Prevention of pollution. Powers are needed to prevent private (or departmental) actions that might prejudice the safety of a water supply. It should be remembered that the river intake of one local authority may be



put at risk by the actions or negligence of an upstream body over which the affected authority has no control.

Plumbing regulations. Once water leaves the supply mains it usually passes into private property, connections being made within the consumer's premises by privately engaged plumbers. Without powers to regulate and inspect their work the main supply may be put at risk by cross connection or other fault, and in any case shoddy plumbing can cause considerable waste.

Protection of installations. Powers are necessary to prevent damage through vandalism, carelessness or misuse; trespass and casual defecation in a protected area (e.g. around an impounding reservoir) may have to be controlled. Where access and recreational use is permitted a standard of hygienic behaviour should be laid down. Even in the simplest of improvements (a village well or protected spring) uncontrolled use may cause hazard or damage - a hand pump is especially vulnerable. As with most of these comments the best protection is an educated and co-operative public, but sanctions may be necessary if persuasion fails.

Code of practice for waterworks employees. Just as the waterworks staff may be hindered by private interference or non-co-operation, so the public may have to be protected from over-zealous officialdom. Rights and duties should be clearly defined on both sides.

If the planners of a water supply programme consider that these and other points might have a bearing on the success of the completed installation they should bring them to the attention of the appropriate government department. While the drawing up or revising of water legislation requires the advice of a legal specialist the engineer can be of considerable assistance in identifying loopholes in existing laws and in foreseeing the consequences of new legislation.

#### h) Water Supply as a planning problem

Reference has been made in a number of places in the foregoing notes to the necessity of having a national plan for water supply improvement if the problem is to be tackled efficiently and comprehensively. Such a plan will normally comprise both long-term and immediate measures, the former outlining strategy leading to a complete coverage of the country, urban and rural, and the latter will show the tactics suitable to the country's current economic overall proposals during a definite period (often five or seven years).

Apart from the specific objectives already mentioned, such as the introduction of standardised designs and techniques, recruitment and training programmes, forward investigations, setting of priorities and the like, a national plan can take into account the acceleration in construction that may be expected to result from increasing experience of all grades of staff, from the planners themselves down to the mainlayers and well-sinkers. A temptation in, say, a five-year programme is to budget for one fifth of the available construction capital each year and assume that output will similarly remain constant annually. This can lead to disappointment with progress initially, and sometimes to unjustified attacks from outside on the credibility of the programme as a whole. Over-optimism in estimating early short-term progress can be damaging to the chances of acceptance of long-term proposals.

Another factor to be taken into account is the necessity of purchasing, early in the programme, tools, construction equipment, transport and of setting up drawing offices, investigation units, accounts systems, stores and other administrative mechanisms. The full benefit from such activities may not be felt until later stages, but expenditure will be needed in the first few years.

Thus two factors - staff inexperience and the call for expenditure that is not capable of producing an immediate return - combine to force up unit costs in the early years and equally to slow down the rate of progress during the same period. For these reasons it is highly desirable to relate short-term activities to a long-term programme so that future potential benefits can be added to immediate progress when justifying early expenditure.

Countrywide planning has so many aspects that there is space here only to list a few considerations, some of which are occasionally overlooked though experience has nevertheless shown them to have an important bearing on success.

- i) Initiation. Some agency (or, more probably, some person) must be sufficiently convinced of the need for planning, and possess the necessary drive and persistence, to stimulate the appropriate authorities into taking the action required to set up a national plan.
- ii) Assessment of national need, immediately and in the future, so that the true extent of the problem can be presented. Included with this must be an estimate of the cost of filling that need in terms of money, manpower and materials.
- iii) Estimates of resources available (and expected to become available) for carrying out the work involved, separated under such headings as foreign expenditure, government (or state) commitments, locally available resources. At this stage financial arrangements must be decided upon in principle, so that an idea may be gained as to the proportion of costs that will be borne by consumers, grants, loans, subsidies or other devices.
- iv) A matching of ii) and iii) to enable long and short-term programmes to be drafted within the limits of practicality.
- v) Deciding upon the criteria that will determine relative priorities when formulating the early stages of the programme.
- vi) A clear and unequivocal identification of who is to be responsible for the various stages of planning, programming, implementation and subsequent management of the various elements of the national plan. The setting up of a mechanism for regular reporting to ensure that each agency is accountable for its particular responsibilities, that targets and progress can be periodically compared, and that shortfalls can be seen and studied with a view to rectification.

The foregoing comments apply to the planning of water supply improvements as such. There is another consideration that must not be disregarded - the water supply element within other forms of planning. Only too often developments, such as schools, hospitals, housing, industry, transport and the like, are planned and approved without due regard having been given to their immediate and future water needs. Where there is a national water plan such an omission can be obviated by close integration of the various programmes, but in all cases it is essential that water supply interests should be represented in the planning of every type of development that could be jeopardised by lack of adequate water, or that could adversely affect other existing or potential users through excessive demands upon restricted resources.

i) Water Supply as a manpower problem

In many countries the greatest single obstacle to successful construction and subsequent management of water supplies is the shortage of skilled and experienced staff. If a countrywide programme is to be prepared it is as essential to forecast the requirements of manpower as it is of funds. Finance may be forthcoming from external sources, but for personnel reliance must be placed on local recruitment (with the possible exception of the temporary employment of a few foreign specialists) and, while funds can be used immediately they are received and allocated, staff have to be trained in advance.

In this context the word 'staff' is loosely used to cover all types of personnel from engineers and managers down to village operatives - anyone, in effect, that can only carry out his job properly after receiving a period of instruction. Such periods may range from a few weeks to as many years, but unless the training is given the health of the consumers and the value of the capital investment of the installations concerned may both be put at risk.

The cost of training is itself an investment, recoverable (with interest, it is hoped) when the trainee becomes an asset rather than a liability to the programme as a whole. There are several ways in which this investment may be wasted, e.g.

- : by selecting the wrong type of candidate, or one without the necessary background knowledge to benefit from training.
- : by failing to have a sufficiently attractive staff structure, with salary and promotion prospects, to retain the skilled men after training.
- : by an unbalanced training programme, leading to the misuse of trained men in carrying out subordinate work (e.g. qualified engineers having to perform draughtsman's, surveyor's or clerk's duties owing to the lack of supporting staff).
- : by failing to anticipate training needs, so that staff are not ready to take over their duties when required.

It is therefore important to plan recruitment, training and staff requirements together and in advance, and also to ensure that the needs of government, local authority and private employees are all taken into account, otherwise there may come a time when all three sectors are competing for an insufficient number of qualified men.

The private sector is the one most frequently forgotten. National firms of consulting engineers should be strongly encouraged as they may make a most valuable contribution to a national programme, but much of this value is lost if they are only able to recruit staff from among existing government employees. In the same way local contractors and private plumbers, to play their proper part in the national plan, must have facilities to engage trained men, or to train their existing personnel, without prejudicing the ability of government departments or local authorities to carry out their respective functions.

Qualified men (in various grades) are required at three stages - planning, construction and subsequent management. With forethought the earlier stages will provide experience for the needs of the later ones, e.g. junior planning assistants will go on to senior posts in construction projects; artisans engaged on construction may become operators of the supplies they have helped to build. When installations are to be handed over to municipalities or other local authorities upon completion it should be a condition that the managerial and operating staffs (or, at least, the key members of these) should be nominated and recruited well in advance - preferably before construction starts - so that they may obtain experience by being engaged at this earlier stage.

Training should be considered as a continuing rather than as a once-for-all-time activity. The best men in any grade should be encouraged and given the opportunity of qualifying for duties with a higher responsibility, their subordinates should be preparing to step into their positions when this happens. In-service training may be effected by a number of methods; e.g. fellowships and short university courses for professional staff; seminars and travelling lecturers for professionals and sub-professionals; summer schools, travelling instructors and demonstrations for craftsmen and artisans. Arrangements whereby operators from small installations work for a time in larger plants, and similar devices suitable to the conditions within a country, are inexpensive but effective ways of raising the standards of the water supply services.

When external firms of consulting engineers are engaged within a country, training of counterpart and other staff (not necessarily restricted to professional grades) may be built into their agreements. They may also be asked to plan and recommend the selection of suitable candidates for external fellowships, such as those granted by various international agencies. When contracts for the supply of equipment and plant are awarded to foreign firms it is often possible to include a provision for training of fitters and maintenance staff, either within the country itself or in the place of manufacture, as part of the conditions of acceptance.

To sum up: the planners of any project or programme should not restrict themselves to the construction of physical facilities, but should advise upon and do their best to ensure that arrangements are made to enable those facilities to be efficiently managed and operated after completion.

## CONCLUSION

### Water Supply as an engineering problem

A successful water supply consists of four parts:

1. An ample and continuous supply of source water.
2. Physical installations to extract, process and deliver this water to consumers.
3. An organization capable of managing, financing and operating the supply under all circumstances.
4. A satisfied body of consumers.

To ensure the last condition the first three are essential. No.1 is obvious, and must be the primary consideration of the planner. No.2 is the result of the combined efforts of a number of disciplines. No.3 is the one most frequently neglected, but its breakdown can be as disastrous as a failure in either of the first two.

No one man can hope to be an expert in all the aspects of water supply. As has been shown (it is hoped) a single installation may call for such varied preparatory work as -

- : An economic appraisal and justification.
- : Meteorological, geological, hydrological, epidemiological, demographical and topographical investigations.
- : Chemical and bacteriological analyses.
- : A study of social and religious traditions of the community.
- : Physical planning

- : Financial planning and the setting up of an accounting system.
- : Legal considerations.
- : Staff planning and training requirements.

To bring together all the disciplines involved there must be a single focal point at all stages, and if this point is to be the engineer (as the author firmly believes it should) it is most necessary that he should understand, and be concerned with, the problems of the other specialists involved.

Whether this engineer is described as a 'water' engineer, a 'sanitary' engineer, a 'public health' engineer, an 'environmental' engineer or other title (according to his country of training and qualification) is of less consequence than his attitude of mind towards his task. The important thing is not so much that he knows everything about his profession as that he realises that his knowledge has limitations. The ability to listen to others, both within and outside his profession, is one of the signs of experience; a degree of humility is another.

In countries such as our own our experience is enlarged by professional contacts with our colleagues, especially at conferences like the present one. Sometimes we fail to realise how much we owe to such interchange of ideas, and how much our counterparts elsewhere may lose through lack of opportunities for mutual discussion. It may be that one of the ways in which we could assist them is by fostering and supporting engineering institutions overseas. It might even be that we ourselves could learn something in the process.