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COMMUNITY WATER SUPPLY AND SANITATION

PROCEEDINGS OF THE MEETING OF THE OPERATION AND MAINTENANCE WORKING GROUP

Geneva, 19 - 22 June 1990

VOLUME 2: CASE STUDIES ON OPERATION AND MAINTENANCE OF RURAL AND URBAN WATER SUPPLY SYSTEMS

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WORLD HEALTH ORGANIZATION

DEUTSCHE GESELLSCHAFT FUR TECHNISCHE ZUSAMMENARBEIT (GTZ)

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PREFACE

The importance of adequate operation and maintenance in order to ensure the sustainability of water supplies cannot be over emphasized. Increasingly external support agencies and national governments are realizing that with somewhere between 30 and 60 percent of all water supply facilities non operational at any one time that operation and maintenance is a key concern.

The World Health Organization recognizes this problem and has been working with external support agencies and national governments to improve the situation. WHO has organized a number of meetings to focus attention on operation and maintenance. A working group was formed as the result of an informal meeting held in the Hague in November 1988. From June 19 to 22, 1990, some 40 representatives of water sector organizations from around the world met in Geneva for the second meeting of the working group on operation and maintenance.

For this meeting a number of the participants prepared case studies describing approaches and strategies in operation and maintenance for rural, urban and peri urban areas in a wide range of countries. Papers were prepared for Zambia, Malawi, Zaire, Sudan, Lesotho, India, Vietnam, Brazil, Mexico, Ghana, Nepal and the Asian region.

This present volume presents these case studies in the hope that they will help decision makers and planners in the water supply sector develop and implement more effective operations and maintenance programmes.

OPENING STATEMENT

Dennis B. Warner, Manager
Community Water Supply and Sanitation, WHO, Geneva

On behalf of Dr. Hiroshi Nakajima, Director-General of WHO, I am very pleased to welcome you to this Working Group Meeting on Operation and Maintenance of Urban and Rural Water Supply and Sanitation Systems. This welcome is extended equally to water supply and sanitation agencies of the developing countries, agencies of the developed countries, and to external support agencies.

Problems

Operation and maintenance is a neglected area. We are all familiar with the sight of broken down handpumps, abandoned sewage treatment plants, inoperative or leaky taps at both communal water points and house connections. Unfortunately, capital development has always received priority emphasis over recurrent operations. It is one of the facts of our sector that it tends to be more fun to build new projects than to repair somebody else's mistake. It often can be harder to correct mistakes of our own. The primary consequence of this preference for capital development over recurrent operations is an unfortunate competition among donor agencies to build new projects with the consequent neglect of operation and maintenance for completed and existing projects. This competition frequently is marked by a lack of standardized processes, technologies, and equipment.

A variety of O & M problems can be seen in urban areas, including generally poor operational practices, inadequate extension of coverage of services, and high unaccounted-for water, often exceeding 50 per cent of the water produced. In addition, there are likely to be high O & M costs and low quality of water delivered.

In rural areas, anywhere from 40 to 60 per cent of the facilities may be out order at any one time. Furthermore, there may be a lack of reliable information, since no one collects data on the O & M problems of rural projects.

Causes of Operation and Maintenance Problems

There are many reasons for poor operation and maintenance. One is that O & M is often neglected during the planning and design phases of project development. In general, too many resources are allocated to design and construction phases compared to those directed towards operations. In addition, there often is poor coordination among External Support Agencies (ESA's) in terms of technologies, standardization, and programme inputs. The construction of new facilities may be very good, but the resulting systems may not be sustainable. This may be due to inappropriate technology or to the fact that O & M responsibilities are rarely well defined. Moreover, recurrent funding for O & M is rarely assured. Other causes include the lack of ancillary facilities (workshops, vehicles, training sites, etc.). In particularly bad situations, administrative and managerial actions may not be taken properly.

Importance of Operation and Maintenance

During the second half of the International Drinking Water and Sanitation Decade a growing concensus arose regarding the importance of O & M. Since 1985, a series of major consultations have stressed the role of O & M. This included the Asia Regional Consultation in Manila in 1985, the African Regional Consultation in Abidjan in 1986 and the Americans Regional Consultation in Washington, D.C. in 1986. In 1987 a Global Consultation was held in Interlaken to reaffirm the Decade concepts of importance. All of these Consultations stressed that inadequate attention was being given to O & M, there were too many inappropriate technologies being used, and there was a great lack of emphasis on rehabilitation of systems.

Lessons of the Decade

The Water and Sanitation Decade is coming to a close. What have we learned from it? Let us quickly review some of the key successes and failures of the Decade. On the success side there has been, firstly, a greater awareness of needs and their causes. Secondly, we have developed new methods and procedures for project implementation. One of the outstanding examples of new technologies arising

from the Decade is the village level operation and maintenance (VLOM) concept. Thirdly, the Decade has clearly shown the great need for coordination between external support agencies and the developing countries.

On the failure side of the Decade, we have, first of all, the problem of inadequate coverage with water and sanitation services. Although perhaps 700 million additional people were served with water over the course of the Decade and perhaps 350 million were served with improved sanitation during that time, the stark fact remains that there are more people on earth today without adequate water supply and sanitation services than there were in 1980. The second failure is our inability to raise sufficient finance to meet the needs of the Decade. And the third failure is our continuing inability to develop sustainable projects. On this issue, the Decade has clearly shown that sustainability is very much related to attitudes, political will, efficient procedures, and appropriate technologies.

Background to the Working Group

The initial idea for paying greater attention to operation and maintenance arose at the Hague Global Consultation in November 1988. The idea of a Working Group on O & M was formed immediately after that meeting for the purpose of giving an overview to the issues and the consequent conclusion that further efforts needed to be given to O & M. The initial agencies active in these initial stages were WHO, IRC, USAID/WASH. This new working group developed a document which became an outline for cooperative action.

The second meeting of the working group occurred in the Hague in February 1990. Attending this meeting were WHO, IRC, GTZ, WASH and UNDP/World Bank. This group reviewed the problems causing poor O & M and developed several objectives for coordinated efforts among ESAs. In addition, the Group identified a variety of follow-up activities to the existing problems.

Our meeting here today constitutes the start of the third meeting of the Working Group. Its general objective is to develop an action plan to improve O & M of water supply and sanitation. More

specifically, we are here to: a) review problems and issues causing poor O & M, b) identify possible remedial actions, and c) develop specific activities for implementation.

It is a privilege to be able to work together on important issues. Make no mistake about it, operation and maintenance is an important issue and one which we must grapple with. These issues in O & M may be old, but the challenge of trying to deal with them, as we are today, in an atmosphere of coordination and cooperation between agencies of developing countries and ESAs gives them a unique flavour, one that is generally unprecedented in the field of operation and maintenance. Ladies and Gentlemen, WHO is pleased to host this meeting and I and all of my colleagues wish you a stimulating and productive week of discussions.

TOWARDS IMPROVED OPERATIONS AND MAINTENANCE PERFORMANCE

J. Kalbermatten
Washington, D.C.

Introduction

During the International Drinking Water Supply and Sanitation Decade, major efforts have been made in attempts to increase investments in Water Supply and Sanitation. Regrettably, investments in increasing operating and maintenance skills have not kept pace. As a consequence, many water systems are not providing the full services they were designed to deliver and the backlog of rehabilitation needs grows year by year.

Operation and maintenance (O & M) is the activity of a water supply and sanitation agency which has the most immediate impact on the user, the value of the service he receives, and his perception of it. Operation and Maintenance should therefore have the highest priority among an agency's activities. Unfortunately, Operation and Maintenance is rarely so regarded by organizations with a backlog of unmet demand (unserved areas). Both the institutions and the decisionmakers in External Support Agencies and governments are under considerable pressure to give priority to extensions and new construction. To make things worse, Operation and Maintenance is so intimately connected to sector and institutional issues that it would be difficult, at best to improve it without an understanding of those larger issues and at least their partial resolution. Moreover, the implementation of Operation and Maintenance programmes should be considered as a priority stage in the process of the institutional development of water agencies.

This paper reviews the broader sector and institutional issues to place Operation and Maintenance in proper perspective and suggests minimum actions and activities to improve Operation and Maintenance. The method of analysis followed is to identify and briefly review an issue, to indicate what action by sector and agency decisionmakers (or External Support Agencies) is required and to suggest activities to assist decisionmakers in the promotion and implementation of Operation and Maintenance

improvements. The information generated should convince decision makers of the priority Operation and Maintenance should have for the achievement of long-term sustainability and thus the economic viability of the sector.

Sector Performance

Inadequate maintenance is a symptom of faulty priorities and lack of understanding of the importance of good operating and maintenance practices by decisionmakers inside and outside the sector as much as it is a problem of inadequate funds or lack of skills. Decisionmakers must be convinced of the benefits of good maintenance before they authorize the allocation of funds and give higher priority to Operation and Maintenance.

To convince decision makers, the cost and benefits of adequate maintenance as well as the costs and disbenefits of inadequate maintenance must be clearly demonstrated. The situation is similar to the often referred to reluctance of economic decisionmakers to accept health improvement claims of water supply projects without a quantification of benefits. Decision-makers must be given quantitative evidence in order to provide financial support, for Operation and Maintenance just as for health improvements. One topic which can be used to demonstrate the costs, benefits and disbenefits of different levels of Operation and Maintenance activities is unaccounted for water. Reduction in unaccounted for water through better Operation and Maintenance increases revenues, reduces rehabilitation costs and postpones future investments, issues decisionmakers in both External Support Agencies and governments appreciate.

Fortunately, it should be easier to produce the evidence in the case of Operation and Maintenance, although with some difficulties caused by the dispersed character of the sector. Unlike electric energy, which can be transported over great distances and thus is usually supplied by enterprises serving large geographic areas, water supply agencies are relatively small in comparison or consist of a large number of individual units. Exchange of experience and information is consequently more difficult and often neglected, leaving individual units unaware of progress made elsewhere. Training, management,

provision of supplies, applied research and development suffer similarly from this dispersion of the sector, particularly in rural areas. Obtaining information on Operation and Maintenance performance, costs and benefits will therefore be an arduous task.

In order to address this situation, government and sector decisionmakers should establish policies giving maintenance adequate priority at all levels of project development, implementation and operation. Specific activities which might be undertaken include undertaking a study of pertinent literature and documentation and preparing a report directed at decisionmakers which:

- Defines adequate Operation and Maintenance performance and quantifies its costs and benefits (for different system components or technologies) on the basis of information available from well managed and maintained water supply systems.
- Quantifies disbenefits of inadequate Operation and Maintenance performance for similar systems, such as early replacement of assets inoperative due to lack of maintenance, on the basis of actual experience.
- Provides a cost-benefit analysis to justify increased support for Operation and Maintenance activities.
- Suggests policies establishing financial support and priority of Operation and Maintenance programmes.

Included in this analysis could be such topics as rehabilitation vs. new construction, maintenance vs. planned obsolescence and similar issues.

Funding of Operation and Maintenance

Inadequacy of maintenance funding is usually assumed to be the cause when systems fail because the operating entity was unable to buy materials or engage a sufficient number of adequately trained staff. Unfortunately, that only answers the question of what is inadequate but leaves unanswered

what amount of funds would be required for adequate maintenance. To budget adequate financial resources, that question must be answered.

With financial requirements known, policy decisions on how to generate necessary funds can be established. To be sustainable over the long term, the user should be able to pay for maintenance or be capable of undertaking the maintenance tasks himself. This is so because governments and External Support Agencies have no direct interest or responsibility in Operation and Maintenance (in contrast to the user), have changing priorities, and thus should not be depended upon as sources for Operation and Maintenance funds except during a short term period of transition.

To optimize investment and resource recovery potential for Operation and Maintenance, projects should be designed for "effective demand", i.e. the user's choice of system or technology based on his own judgement of acceptability, willingness and ability to pay (in case or in kind). Design for effective demand requires the project developer to work with the user community. This often results in an iterative process to find the solutions which are acceptable and affordable. The intensity of community participation varies greatly, reflecting the likely technical option. For complex urban systems, users may be asked to approve the broad concept only, while in small communities, periurban and rural areas the user may participate in decisions about layout, technology choice and financing.

Government and sector decisionmakers, including those of External Support Agencies, should include in their cost recovery policies the requirement that long-term sustainability of investments must be achieved and that in an effort to do so, projects should be designed on the basis of effective demand, should specifically assess Operation and Maintenance requirements, and provide for agency, community or user capacity to undertake or finance Operation and Maintenance.

To help provide decisionmakers with the information necessary to determine the financial requirements of the proposed cost recovery policy, a study should be initiated which analysis the financial requirements for Operation and Maintenance or develops a methodology or a model on how to determine

financial requirements for Operation and Maintenance for individual projects. The research should also compile a matrix relating investment and Operation and Maintenance costs for different systems or technologies and describe maintenance needs of technologies listed in the matrix.

ESA Support

External Support Agency (ESA) support has to be based on the recognition that governments are responsible for determining sector policies and priorities and that, ultimately, users must sustain the services they choose to receive. External Support Agencies, in assisting governments and users, can make significant contributions in accelerating progress of the sector, not only by making funds available but by providing advice and information on policy issues, assistance in policy and guideline formulation and support through adopting appropriate policies themselves.

For example, External Support Agencies should give preference to financing projects designed on the basis of effective demand and encourage cost recovery policies which require the user to be ultimately responsible for Operation and Maintenance (in kind or cash), even if this requires a relaxation of procurement rules (tied aid), if their application would result in the use of "inappropriate" technology or equipment.

This imposes on External Support Agencies the responsibility to ensure its staff evaluates projects in accordance with these principles and that the consultants they fund for project preparation are skilled in designing projects for effective demand.

External Support Agencies should also encourage their clients to make better use of management information systems designed (among other things) to provide the data necessary to determine the cost of Operation and Maintenance and its impact in order to be better able to judge the adequacy of Operation and Maintenance. The system should include appropriate indicators for the monitoring and evaluation of Operation and Maintenance and arrangements for feedback to system designers so lessons learned will be incorporated in future designs. External Support Agencies should review their policies to

ascertain that they are compatible with the objectives of effective demand design and long-term sustainability through the users own efforts. If necessary, existing guidelines should be adapted. Subsequently, their consistent application should be ensured on projects financed with ESA financial support. There are several specific activities which ESAs could undertake. These include the preparation, for their own use and that of developing country agencies they support of:

- Guidelines and training materials on how to develop and implement projects designed on the basis of effective demand. These guidelines would be for ESA and sector agency staff and their consultants and could be adapted by individual External Support Agencies to meet specific demands.
- Guidelines and indicators for the monitoring and evaluation of Operation and Maintenance performance.

Individual External Support Agencies should define how they will provide feedback to designers about the performance of their designs to ensure that necessary improvements will be made in future designs. The "lessons learned" feedback process should be automatic.

The preparation of the guidelines should be followed by appropriate training of ESA and sector staff and their consultants.

Appropriate Use of Technology

To be appropriate, technology must be least cost, financially affordable and socioculturally acceptable to the user. Where there is any doubt that this definition refers to both investment and operation, additional phrasing such as "and maintainable by the user either through his own labor or by payment to a public or private operating enterprise" may be added. Projects designed in accordance with the principles of effective demand meet these conditions.

This approach not only allows the user to decide what he is able and willing to pay, but it requires the designer to base his designs on cost and/or ease of maintenance of the technology selected. Experience shows that it cannot be simply assumed that needed operators will eventually be trained. It

also means that the operators (users or operating agency employees) need to be consulted in the design process.

Sufficient information is available about appropriate technologies for this process of consultation except on the topic of maintenance, particularly its cost. External Support Agencies and developing countries should agree that the appropriate use of technology as described above is a fundamental requirement in the development of joint projects. To ensure implementation, projects are to be designed on the basis of effective demand, i.e. giving the user a voice in defining what is acceptable and affordable to him. Project design is to explicitly consider the ability of the user to maintain the constructed facilities or pay for their Operation and Maintenance. If necessary, policies and guidelines should be amended to reflect this requirement.

To avoid problems of past project development when initial costs only were considered and insufficient attention was paid to the complexity or cost of Operation and Maintenance (particularly when hardware was made available at concessionary terms), the guidelines developed by External Support Agencies for staff and consultants should include specific instructions on the evaluation of Operation and Maintenance appropriateness. These should be made available to implementing agencies.

System Performance

Even a system using appropriate technology may perform poorly if design was inadequate, construction shoddy or using faulty construction techniques, materials were of inadequate quality or inappropriate to local conditions. Participation in the construction supervision by those who will operate the system helps overcome the problem.

The use of materials not locally or in country available, such as treatment chemicals, can result in performance defects even with the best Operation and Maintenance staff and procedures if foreign currency is not available to the operating agency. The same is true for spare parts not locally available. Design can minimize this problem, of course.

Poor system performance can also be caused by events not under the control of the operating agency. For example, upstream water pollution may exceed treatment capacity, diversion of scarce water resources (illegal or legal) for other purposes may cause severe supply deficiencies, regardless of operating skills.

In periurban and rural areas, operational responsibilities are at times ill defined and can also result in neglect of Operation and Maintenance activities. Coordination arrangements with other institutions, especially where community participation is an important factor and hygiene education a need, is a must if long-term sustainability is to be achieved.

Implementation of quality control monitoring for manufactured goods and construction, followed by corrective action, is important. The promotion of local production of necessary equipment and material and the use of adequate chemicals or disinfectants locally produced should be encouraged. However, where these locally produced materials, including chemicals, are not suitable their substitution for improved materials should be encouraged (development of better products or purchasing of imported materials).

Strengthening collaboration with other agencies in an effort to overcome water pollution and scarcity problems should be an integral part of water supply management in an effort to overcome related Operation and Maintenance problems. National governments should also issue appropriate guidelines and directives to implement quality control, promote local manufacturing and ensure adequate interagency cooperation.

A review should be undertaken in selected countries to determine the adverse impact on projects dependence of materials not locally available and the effect the lack of adequate spare parts distribution has on system performance. This should lead to conclusions as to what substitutions would be possible, and what design changes in future projects may make such substitution easier to implement. Appropriate

design guidelines could then be developed to encourage the engineer to investigate materials availability prior to design and to select process modifications to reduce Operation and Maintenance problems.

Based on the results of the review, a study should be conducted in appropriate countries to determine the feasibility of establishing local manufacturing of equipment, spare parts, materials and chemicals (or substitutes). Subsequent establishment of manufacturing capacity could be part of a water supply investment or a separate project.

Also guidelines on how to determine the feasibility of and promote local manufacturing of spare parts and materials should be developed from these studies in an effort to solve related Operation and Maintenance problems for the long term in other countries.

Institutional Performance

A properly designed and implemented water supply system provided with adequate financial resources depends for its long-term sustainability on the institution in charge of its management. Indeed, inadequate Operation and Maintenance is tied to many institutional problems, most of which are not amenable to corrections without major institutional changes. Clearly, those exceed the capacity of Operation and Maintenance units to modify. The following recommendations address those issues which can be at least partially improved by the operating institution for the benefit of Operation and Maintenance.

Systems will invariably fail as long as the institutional environment concentrates on expansion and neglects Operation and Maintenance. Governments and institutions should recognize that the fundamental purpose of an operating organization is to operate, not to build. That is obvious to a "mature" organization, where capital expansion is a relatively small part of activities. Until developing countries' organizations behave as operators rather than builders, they will forever be building because their neglect of maintenance will require them to rebuild deteriorated assets. Funding allocation between

new construction and rehabilitation and maintenance therefore needs to be reconsidered, and organizational arrangements changed to reflect higher priority for Operation and Maintenance.

The traditional public utility arrangement frequently is not effective for periurban and rural areas where community participation is an essential ingredient of successful project development and Operation and Maintenance. The institution must become multidisciplinary, employ behavioral scientists and public health specialists to work with the users, and establish, as part of its own organization or separately, support structures to help the community with tasks of a technical nature it cannot accomplish by itself alone. A multidisciplinary team will also be in a better position to work with other institutions to arrange for corollary activities, for example the hygiene education of the users by the ministry of health.

The participation of the user in the design and implementation process, and his responsibility for Operation and Maintenance, requires the operating agency to pay much closer attention to monitoring and evaluating the performance and impact of the project so lessons learned can be incorporated into future designs. The planning process is no longer one of developing a masterplan with a first stage project for those who can afford a given service standard (technology), but one of preparing a dynamic plan responsive to user preference, i.e. various standards depending on affordability and willingness to pay. Because they change over time, monitoring will indicate needed changes and provide lessons for future project design.

The role of the private sector in the provision of support services to the community, particularly in Operation and Maintenance, should be considered. Private entrepreneurs are often the supplier of last resort when water is not communally available, usually at high marginal costs. However, entrepreneurs may be able to provide repair and maintenance service more quickly and at lower cost than a centralized institution, especially in periurban and rural areas. Specific tasks, such as computerized billing, leak detection, treatment plant operation, etc. may also be candidates for contracting to the private sector in

an effort to make the service more efficient and less expensive in urban areas. The engagement of the private sector in Operation and Maintenance should be carefully considered in the context of an institutional development process, without losing the perspective of the need to ensure the sustainability of this process.

In most developing country institutions, the way to a successful career is through design and construction activities, not by being an excellent Operation and Maintenance manager. Not only do Operation and Maintenance activities suffer from this, but future projects do not reflect operating experience. To change this, institutions should establish career-paths for operating personnel which are as attractive as those of design and construction staff to encourage talented young staff to consider operations as an option. The chief of operations position should be on a level equal to that of the capital works or chief engineer, with veto power over new project designs. No senior staff appointments should be made of candidates who do not have experience in both operations and design/construction. Training activities should reflect this approach.

The organizational structure of the traditional centralized institution has to be modified to make it more responsive to the needs of the periurban and rural population. Whether this adjustment will be essentially a reorganization of an existing institution or the creation of new agencies will depend on local conditions and government policies for the sector. In either case, an institutional structure has to be implemented which is designed to support local communities and users in their own efforts to develop, implement, operate and maintain systems in periurban and rural areas where the traditional centralized operations have been largely unsuccessful.

Privatizing can be interpreted to imply anything from contracting for minor services to complete private control of the provision of water supply services. In this context it means contracting for specific services, complete privatizing being beyond Operation and Maintenance purview. Appropriate policies

should be enacted to give an agency the opportunity to contract for specific services if they prove to be efficient.

Suggested activities which could be undertaken by ESA's and or national governments to improve institutional performance are:

- To study organizational structure and personnel policies of the Operation and Maintenance complex (and its status within the organization) of successful developing and developed country operating organizations and develop models for implementation by other organizations. Included in the analysis and the model should be an assessment of the cost of modifying the organizational structure.

- To investigate alternative arrangements of organizing water and sanitation support structures, capable of working with the community and the user in Operation and Maintenance, suitable for periurban and rural areas and recommend, if deemed necessary, testing and demonstrating appropriate models. Particular emphasis should be paid to the needed relationship between centralized urban utilities and local community organizations serving periurban neighborhoods. In the rural areas, attention needs to be paid to spare parts distribution. Because Operation and Maintenance cannot be entirely separated from other institutional considerations, this study should include overall institutional aspects. It should therefore preferably be based on or included in institutional improvement projects.

- To determine the cost of specific unidentifiable tasks, such as meter reading and billing, maintenance of treatment plants or isolated rural facilities, network of spare parts provision, technical assistance to community organizations, and evaluate whether services of private entrepreneurs or nongovernment volunteer organizations would be less expensive, more responsive or more efficient. If private provision of such services is found to be more effective, appropriate policies and contracting procedures should be developed to encouraged privatizing of these services.

User Participation

The traditional engineering approach is to identify a problem, design a solution, construct the resultant project, and leave Operation and Maintenance considerations to local authorities. With the effective demand based design method, this is no longer adequate, except in the case of complex urban projects. Now the user, individually and as part of a community, participates in the decisionmaking process, beginning with project identification through all the intermediary steps ending with the decision as to how the system is to be operated and by whom. As a consequence, the responsible institution must equip itself to work with the community, both by adapting its structure and by engaging appropriately qualified staff.

In the rural and periurban area, community participation will probably be intense as a general rule. In central urban areas, community participation will probably involve traditional public utility marketing practices, supplemented by more intense efforts at convincing consumers to conserve water through modifying personal habits and the use of water saving appliances. This is because the standard of service in densely populated areas is not amenable to individual choice (economies of scale determine technology to be used) and other decisions, method of water treatment for example, require expertise users ordinarily do not possess.

User participation in project design is important not only because it allows a determination of willingness to pay, but it permits the user to determine his involvement in Operation and Maintenance activities. Without it, there is no reason to expect user involvement in Operation and Maintenance. User participation also has to include an appropriate degree of hygiene education to be successful: the user must understand the health aspects of safe water, technology selection and personal hygiene behavior. For example, the user needs to understand and practice the protection of water quality within the household (and while carrying water to it) to benefit from improved water quality and to maintain the facility which provides it.

Community participation is recognized to be the key to long-term sustainability of water supply and sanitation facilities in periurban and rural areas. How to organize and maintain user interest, and how to help user in their tasks of operating and maintaining systems is well known among behavioral scientist field staff and community workers. The problem is that traditional public utility staff, in keeping with institutional priorities, have little interest or incentive to promote community participation. Overcoming this problem requires an intensive effort of education, preferably in parallel with such institutional changes as are necessary. Documentation for such an educational effort should be assembled and prepared to suit the needs of the audience. This should not lead to a belief that education alone will be sufficient. Institutional attitude and organizational modifications are necessary, and staff qualified in community participation and user education have to be engaged to complement institutional technical staff who, however willing, will not acquire overnight the necessary skills to implement projects based on community participation.

Institutions have to organize staff units capable of working with the community in improving Operation and Maintenance. The training of present staff is essential and it may be necessary to engage additional staff (community workers).

In order to improve the participation of the consumers in operation and maintenance national governments and project staff should review available user and community training materials, identify gaps and prepare missing documentation. Gaps are likely to be found mostly in the documentation for training/sensitizing of institution staff. Institutions should also be prepared to assist in the preparation and implementation of the necessary training activities. Again, the greater need is probably in the training of institution staff because in the past community work has been primarily undertaken by volunteer organizations.

Summary and Conclusion

There is an urgent need to promote adequate Operation and Maintenance of water supply systems so more people can be served on a sustained basis. It is in the interest of operating agencies to properly maintain their systems so they can successfully provide the services expected and attract additional funds for system expansion. It is of equal interest to External Support Agencies and Governments to ensure that the systems they have helped finance are properly maintained: a) to protect their investment, because without it does not make sense to continue investing in the sector and: b) a malfunctioning system does not contribute to economic development.

A cooperative effort between national governments and External Support Agencies is required as there is a need to agree on the importance and the methods of improving Operation and Maintenance performance. Actions can be implemented individually, but a general agreement on how to proceed is necessary to make efforts more effective.

Finally, exchange of information on cost, methods and benefits of proper Operation and Maintenance can help each individual government and ESA to improve the effectiveness of its own programmes, and networking on specific activities can increase the impact of individual efforts.

A strategy to reach the objective of improved Operation and Maintenance should include:

- Defining the activities needed to generate the information necessary for developing policies and programmes.
- Consulting with other programmes engaged in the procurement of information on similar topics to expand the database.
- Promoting and supporting the elaboration of policies and programmes and propose their implementation to decisionmakers in countries and External Support Agencies.
- Assisting in the implementation of policies and programmes.
- Monitoring the implementation and evaluate the results.

and - Suggesting and supporting the reformulation of policies and programmes, as indicated from monitoring, to obtain expected benefits.

A STRATEGY FOR SUSTAINABILITY OF RURAL WATER SUPPLIES IN THE SUDAN

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Introduction

Sudan, one of the poorest countries in Africa is plagued by a myriad of economic, political and environmental problems. The country's infrastructure is deteriorating rapidly, the country has one of the highest foreign debt loads in the world, food and goods are in short supply, recurrent droughts are a way of life and the economic prognosis is for a further worsening of conditions in the immediate future.

The central government has barely enough funds to provide essential services at the most basic and rudimentary of levels. For example, many elementary drugs such as aspirin are almost impossible to obtain.

Water supply and sanitation service levels are low and while it is very difficult to obtain accurate figures for coverage the most generally quoted sources place rural water coverage at 30%, urban water coverage at 40%, rural sanitation at 10%, and no data are available for urban sanitation.

These figures, however are inflated as the existing water and sanitation systems in most parts of the country have deteriorated to the point where they simply do not function.

In the Sudan, like many countries in the developing world, a major issue in the water supply sector is operation and maintenance. Donor funds are usually available to build systems but ensuring their sustainability is problematic. In the Sudan due to economic and political problems, operation and maintenance of water supply systems has been seriously neglected and the country is currently faced with a massive deterioration of its rural water systems.

In 1986, the World University Service of Canada, with funding from the Canadian International Development Agency (CIDA) and the United States Agency for International Development (USAID)

developed a project to rehabilitate 15 water systems and construct 10 new ones in Northern Darfur Province. The project area is one where settled agriculturalists and nomadic livestock herders coexist. The major concern from the perspective of the external support agencies from the outset was the sustainability of these systems. It seemed fruitless to rehabitate old water facilities or construct new ones if they were likely to fail in a short time due to lack of operation and maintenance. Thus a major goal of the project was to develop and institutionalize an operation and maintenance strategy to ensure the long term sustainability of the wateryards.

A second objective or a hope was that the operation and maintenance strategy developed might serve as a model which the National Rural Water Corporation (NRWC) could utilize, with modification, in other regions of the Sudan.

This paper describes this operation and maintenance strategy and its performance to date.

Water Sources

In western Sudan, common rural water sources include both surface water (ponds and haffirs) and groundwater (shallow alluvial, shallow perched and deep aquifers). The only reliable, long-term supply of a suitable physical, bacteriological and chemical quality is groundwater. During severe droughts, which occur with great frequency only deep aquifers can be relied upon as rural water sources. Northern Darfur Province is underlain by three major deep aquifer systems: the Nubian Sandstone Formation, the Umm Ruwaba Series, and fracture zones in the Basement Complex metamorphics. Unlike other areas of western Sudan where these aquifers can be developed with moderate depth boreholes equipped with handpumps, in Northern Darfur Province boreholes are often in excess of 200m to tap these aquifers and motor-powered pumping equipment is essential.

A wateryard is a rural water supply point consisting of one or more deep boreholes each equipped with a pump and diesel engine. Water is pumped to an elevated steel storage tank and then

distributed through steel pipes to tap stands, to livestock watering troughs, and often to a tank-filling facility. The wateryard is fenced to control the various water uses and to provide security.

There are some 3000 wateryards with approximately 3500 boreholes in the Sudan. Most of the wateryards were constructed in the 1960's and early 1970's during Sudan's "Anti Thirst Campaign". The wateryards have not been properly maintained and it is estimated that perhaps 50% or more are non operational and that 80% need major rehabilitation.

In Northern Darfur Province, there are 134 wateryards and approximately 65% of these wateryards function at greatly reduced capacity due to age, and deterioration of the equipment and the lack of proper operation and maintenance.

Wateryards are owned by the government and administered by the National Rural Water Corporation (NRWC). With the present system the NRWC sells water to the community and also to nomadic groups migrating past the wateryard. The NRWC operator looks after the pumping equipment and performs minor maintenance and repairs while an NRWC guard provides the needed security. Water revenues are collected by the clerk and sent to the NRWC regional office and then remitted to the government treasury in Khartoum. Regional NRWC personnel in return provide fuel, lubricants, maintenance and repair services to the wateryard out of an annual maintenance budget provided by NRWC Khartoum headquarters. That at least is the theoretical institutional arrangement.

In reality, however, this system does not work and the wateryards are poorly maintained if at all. The NRWC obtains an annual appropriation from the government to administer the rural water systems but the government of Sudan is experiencing severe economic hardships and understandably water supply is not a priority. The result is that the NRWC does not receive sufficient funds to properly operate and maintain the wateryards and the majority are either not functioning or operating well below capacity.

In addition, the water revenues forwarded to Khartoum are substantially less than those collected. Most wateryards do not have a water meter or any method of verifying the quantities of water

pumped. Consequently the amount of money sent to Khartoum depends on the honesty of the wateryard clerk.

To keep wateryards at least functioning an unofficial community based system has developed in some regions. The community, in addition to paying the NRWC rate also has a community water clerk who collects an additional charge. These monies are used to buy fuel and spare parts on the "black" market and to pay for repairs. Consequently, the real cost of water to the consumers is often two to three times the official rate.

Operations and Maintenance Strategy

The operation and maintenance issue is one that external support agencies in the Sudan have long been aware of. There have been attempts in the past in individual projects to implement operation and maintenance programmes in water projects. In many instances, however, the external support agencies have simply by-passed the government and the relevant government agency, the NRWC, and set up operation and maintenance systems which were specific to their project.

This resulted in operation and maintenance approaches which worked as long as the external support agency was involved and active. As soon as the external support agency left the operation and maintenance system collapsed.

The World University Service of Canada project took the approach that any operation and maintenance system, to be successful and sustainable, must be accepted and institutionalized by the government. Therefore from the project's inception the project worked closely with the National Rural Water Corporation to gain acceptance and approval for the strategy which was evolving.

Initially the NRWC was resistant to the inclusion of an operation and maintenance strategy in the programme. Their attitude was that the Sudan was grateful for the assistance of Canada and the United States but felt that once the wateryards were completed they should be turned over to the NRWC to operate and maintain according to the prevailing system.

The approach adopted to obtain the collaboration and support of the NRWC in the development and implementation of the operation and maintenance strategy was to:

- Host a two week training course on low cost technologies in the water and sanitation sector which emphasized cost recovery, the need for sustainability and a viable operation and maintenance system. This raised the profile of operation and maintenance and made NRWC personnel more aware of the problem.
- Hold numerous meetings with the NRWC and the Ministry of Finance and Economic Planning, which has overall responsibility for water supply and energy resources to describe the proposed strategy and obtain their input and support.
- Host two major workshops, one in May 1989 and the second in May 1990, which focussed on the operation and maintenance of rural water supplies in the Sudan.

These conferences, meetings and training courses contributed to a continuing dialogue on operation and maintenance and resulted in the NRWC agreeing to allow the project on an experimental basis to implement a community based operation and maintenance system.

The operation and maintenance strategy is a community based one in which essentially the community and the NRWC cooperatively manage the wateryards. The water rates collected are paid into a community owned bank account and the community in turn pays the NRWC for operation and maintenance services plus an overhead for the provision of fuel, lubricants and spare parts. The bank account is held in the local bank in El Fasher and signatures from both the Community Water Committee (CWC) and the NRWC are required on cheques.

The operation and maintenance strategy was set forth in a legal Operation and Maintenance Agreement which was signed by the NRWC, the Ministry of Finance and Economic Planning (MFEP) and the World University Service of Canada in June 1988. This legal agreement initiated the process of institutionalizing operation and maintenance procedures.

A major breakthrough in the agreement was the obtaining of permission from the NRWC for communities to establish a community water fund into which all water revenues were paid. At the time the agreement was signed, this was not allowed under Sudanese law and in fact only became legal in 1990 when the new government passed a decree under which wateryard revenues are to be retained in the provinces.

The role of WUSC was to act as a catalyst and to facilitate the initiation of the operation and maintenance strategy. The main articles of the Operation and Maintenance Agreement as set forth were:

- The establishment of a revolving fund into which all wateryard revenues are deposited and coded for each individual wateryard.
- The upward revision of water rates to realistic levels of 5 piastres per jerrycan (18L). This was shortly changed by mutual agreement to 10 piastres per jerrycan.
- The joint management of the revolving fund by WUSC, the NRWC and the community served. Surpluses in the fund are to remain the property of the community. WUSC is only to be involved until the project ends.
- The establishment of community water committees at each wateryard.
- The establishment of record-keeping procedures for the collection, remittance and disbursement of wateryard revenues, and for pump operation times, fuel consumption and water consumption.
- The regular provision of fuel, lubricants and spare parts on a cost-recovery basis by the NRWC.
- Emphasis on preventative maintenance of wateryard equipment by training community pump operators, and by the provision of regular preventative maintenance inspections by the NRWC on a cost-recovery basis.

- Regular reporting of the performance of wateryards and the revolving fund credits, debits and balances to the community water committees.

Within the agreement, provision was made, as an experiment, for one wateryard to be entirely community managed with input from the NRWC only when specifically requested by the community water committee.

Implementing the Operation and Maintenance Strategy

A community development team was formed by the project to implement the O/M strategy. The team consisted of:

- A part-time consultant from the Institute of Environmental Studies who has had many years experience planning, monitoring and evaluating rural water projects and programmes for government, and external support agencies. The consultant was born and raised in Northern Darfur Province and is familiar with prevailing local social, cultural, political and economic conditions.
- A full-time community development specialist (B.A. Sociology, University of Khartoum) originally from Northern Darfur Province, who has had about 10 years work experience in both the public and private sectors as a community worker, social worker, and a logistics manager.
- A full-time community development worker with work experience in northern Sudan, who is also a qualified accountant (University of Juba) and who has had considerable experience in financial management and expenditure control.

The focus of the WUSC strategy is the community water committee (CWC) formed for each wateryard. In consultation with tribal and political leaders in the community and through a process of discussion and negotiation, a CWC of eight to twelve members is formed with an elected president and

secretary/treasurer. Care is taken to ensure representation of all tribal and interest groups from the community and the surrounding service area.

The CWC is encouraged to actively monitor the rehabilitation or construction activities and community participation is encouraged during the rehabilitation or construction process. The fencing of the wateryards with local materials is usually carried out by the community or in some cases supervised by them.

The CWC selects 2 individuals to be trained as a wateryard clerk and a wateryard operator. These individuals receive instruction from project staff during the wateryard rehabilitation or construction process to ensure complete familiarity with the pumps, motors and other equipment. The community development team trains the wateryard clerk in control of water sales, revenue collection, daily recording, monthly report preparation, and the deposit of funds into the revolving fund. The O/M coordinator and a technical training officer instructs the wateryard operators in operation, routine and preventative maintenance of the pump, engine and other wateryard equipment, as well as daily operational record keeping including water meter and hour meter reading and fuel consumption.

In this experimental phase the NRWC also maintains a clerk and an operator in the wateryard along with one or two guards. In larger wateryards the presence of two sets of staff, one from the community and the other from the NRWC does not present a problem as the wateryards are always very busy. However, in the smaller wateryards there is obviously a duplication. In time, it is hoped when the operation and maintenance concept is wholly accepted by the NRWC that the NRWC staff can be redeployed to other wateryards or positions.

Once a wateryard has been rehabilitated or constructed, thoroughly tested and the wateryard personnel trained, the wateryard is handed over to the CWC. Water is charged for at the following rates:

- 10 piastres for 18L jerrycan
- 10 piastres per goat or sheep

- 20 piastres per donkey
- 30 piastres per cow
- 40 piastres per camel
- LS 0.20 per goat skin (36L)
- LS 0.80 per donkey load (4 skins)
- LS 1.20 per barrel (200L)
- LS 2.60 per cart load (2bbl)
- LS 5.00 per cart load (900L)

There are approximately 12 Sudanese pounds to the U.S. dollar and 100 piastres to the pound.

Operation and Maintenance Service Group

A key element in the operation and maintenance strategy is the operation and maintenance service group which has been set up to provide preventative maintenance services to the wateryards as well as to undertake major repairs as required and to generally oversee the operation and maintenance structure. The service group is housed in the NRWC regional office and uses the facilities of the NRWC stores and workshops. The service group consists of:

- An O/M coordinator to manage the technical aspects of O/M such as fuel supply, preventative maintenance, workshop organization, and store inventory control.
- An O/M community development worker to provide support to the CWC's and the NRWC.
- Four artisans (pump mechanics, a plumber and a general mechanic) to provide regular preventative maintenance and repair services to wateryard equipment.

The operation and maintenance (O/M) coordinator and community development worker visit each wateryard and community water committee at least once a month. Meetings are held with each CWC to discuss and resolve O/M problems, to receive the wateryard revenues collected, and to present a

wateryard revolving fund account statement. The team has a vehicle, equipped with a radio to contact the NRWC regional office or the preventative maintenance teams. The four artisans are separated into two preventative maintenance teams, each equipped with a vehicle and a radio.

It is anticipated that the service group which consists of 6 personnel, will be able to service 30 to 40 wateryards when fully operational. The cost of maintaining the service group will be paid for by the individual wateryards on the basis of an annual levy.

Some initial cost estimates have been made for providing this service. It is estimated that the total annual cost of supporting the service unit is approximately 400,000 LS (32,000 US$). These costs include all wages and allowances for personnel, vehicle operation costs, depreciation costs for the vehicles based on a 5 year life span and a 30% administrative overhead for the NRWC. Currently the service group is being supported by the project to allow the community to accumulate a surplus.

Performance of the Operation and Maintenance Strategy

The financial performance of the 4 wateryards where the operation and maintenance strategy has been fully implemented has been closely monitored and documented.

The four wateryards are Tabit, Shengel Tobia, Musko and Sharafa 1. The first three wateryards are managed cooperatively by the community and the NRWC while Sharafa 1 is exclusively community managed. Each wateryard serves a settled population of between 3000 and 6000 settled people together with their livestock as well as migratory nomadic groups and their livestock. It is worth noting that about 70% of the water drawn at the wateryards is used for livestock watering. The one newly-constructed wateryard managed completely by the CWC is Sharafa 1. This wateryard is located in a relatively recently settled area and serves a settled population of some 3000 people and their livestock scattered in a 30 km radius around the wateryard in 11 small villages and about 35 micro-settlements. The service area for each wateryard is about 30 km or approximately 6 hours walking.

The intensity of the pumping varies at the wateryards depending on the season. Tabit averages 359 hours of operation per month, Shengel Tobia 432, Musko 329 while Sharifa 1 which services a smaller population averages 122.

In calculating operation and maintenance costs, actual values as of March 1990 were used plus a 30% administrative overhead charged by the NRWC on fuel, spares, lubricants and wages for the wateryard staff. The costs of the four wateryards have been monitored since July 1989 and data are available through to March 1990.

TABLE I

	Revenue Ls (average monthly)	Cost Ls (average monthly) (excluding O/M service group)
Tabit	9280	3910
Musko	11,505	4051
Shengel Tobia	11,122	4351
Sharafa 1	4451	1444

Table I shows actual average monthly revenues for the four wateryards together with the costs of operation and maintenance. However, the costs of the service group have not been included. The cost of the service group based on the group only servicing the 12 project wateryards is estimated to be on average 2500 Sudanese pounds per month. When the group is fully functional and services the 30 or more wateryards it is capable of, the cost of the O/M service group at each wateryard will decrease substantially.

What is clear from these initial data is that the wateryards are financially viable and that the revenue generated is allowing surpluses to build up in community bank accounts after all costs including the 30% NRWC administrative overhead are deducted.

In the past a serious problem at wateryards was corruption. It was generally accepted that the revenues sent to Khartoum were significantly less than those collected at the wateryards. When the

wateryards were first built meters were installed. However, usually these quickly were broken leaving the NRWC with no accurate way to verify the amount of water pumped. The WUSC project installed water meters and hour meters at each wateryard to accurately measure the amount of water sold. Water sold at each wateryard is determined by daily water meter readings, correlated to daily pump hour meter readings.

TABLE II

WATER DEFICITS AS % OF WATER PUMPED

						89			90
	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Tabit	22	12	11	10	9	8	11	13	16
Shengel Tobia	14	18	27	10	14	10	11	11	12
Musko	-	-	-	-	8	(17)	1	5	11
Sharafa 1	26	38	34	9	(4)	7	9	14	15

() Note: During this month more water was sold than pumped.

As shown in Table II there is often a shortfall in monthly revenues. Some wateryards (for example Musko) perform better than others. At three wateryards (Tabit, Shengel Tobia and Sharafa 1) shortfalls reached unacceptable levels (greater than 15%) early in the implementation process. This was corrected by tightening record keeping procedures and by informing the CWC of losses in revenue. An acceptable loss of up to 15% in revenue is justifiable on the following basis:

- Minor leaks periodically occur in wateryard equipment, or taps are occasionally left open.
- Goat skins are usually soaked and other containers are rinsed before filling.
- It is virtually impossible to accurately count each head of livestock coming to the wateryard, and some animals may drink more than their expected share.

To ensure the long term sustainability of the operation and maintenance strategy it is essential that it be institutionalized and become part of government policy. The process of institutionalizing is already well advanced. One session of the May 1990 conference on Operation and Maintenance of Rural Water Supplies in the Sudan was chaired by the Director General of the National Rural Water Corporation who strongly endorsed the operation and maintenance programme in Northern Darfur. The NRWC also, in separate meetings with external support agencies proposing to undertake water projects in Sudan, stipulated that their projects should include the WUSC Darfur model for operation and maintenance.

In early 1990, the government passed a decree enabling wateryard revenue funds to be administered on a regional basis. These funds are to be used specifically for wateryard operation and maintenance and kept in the region. The passing of this decree was an important step in the institutionalization of the operation and maintenance strategy as it legalized the communities' right to retain funds and have community bank accounts.

Summary and Conclusions

It is still a little early to judge the long term viability and success of the operation and maintenance strategy adopted in the Northern Darfur water project. However, the prognosis at this point is favourable and all the indicators suggest that this community based operation and maintenance system will be sustainable. The presence, in the Darfur area of an unofficial community based O/M system prior to the project no doubt contributed to the likelihood of its success. The project O/M strategy institutionalized and developed this unofficial system and in the process also lowered water tariffs.

External support agencies and local governments are increasingly focussing their attention on cost recovery both for operation and maintenance and system expansion. The preliminary data from Darfur indicate that at a modest base water rate of 10 piastres per 18 litre jerrycan, the operation and maintenance costs are fully recoverable and even allow for a modest surplus to accumulate in the

community water fund bank account. It is worth noting that prior to the project the people were sometimes paying 2 to 3 times the 10 piastres per jerrycan rate.

The present operation and maintenance strategy is based on full cost recovery for operation and maintenance but no provision has been made for capital cost recovery or system expansion. However, a 30% administrative charge is paid to the NRWC and possibly this could be increased to perhaps 50% with no additional hardships to the community. These additional funds paid to the NRWC could then be applied to the rehabilitation of other systems. In this way the government of the Sudan could finance water supply system expansion and rehabilitation and become less dependent on external support agencies.

The project operation and maintenance strategy experimented with two models. Three of the wateryards were cooperatively managed by the community and the NRWC while the fourth, Sharafa 1 was managed entirely by the community. It is difficult to judge at this point which system will be more successful. After less than a year the Sharafa wateryard is functioning very well and revenues are steadily building up in the community water fund bank account. Sharafa is free to contract for its O/M services, either from the O/M service group or from any other contractor. However, one possible danger with an entirely community based system which is not committed to the regular O/M services provided by the O/M service group is that preventative maintenance may be neglected and repairs will only be undertaken when absolutely required.

The operation and maintenance strategy will undoubtedly face several problems in the future. The first issue is the continued existence of the operation and maintenance service group. This group is essential to long term preventative maintenance and repair. There is a danger that the group could be assimilated into the NRWC and lose its identity. If this were to happen the viability of the operation and maintenance strategy would be severely stressed.

A second potential issue is the surpluses accumulating in the community water fund. In the future these surpluses may prove a temptation either to the government or the community. The

government may be tempted to charge higher rates for their services and the community may wish to apply the surpluses to other purposes.

Experience with the Northern Darfur project has shown that the development of an operation and maintenance strategy takes time, patience and continual dialogue and negotiation with both the government and recipient communities. However, in the Sudan situation, the government which initially resisted the idea of a community based operation and maintenance system has turned around and now the NRWC strongly endorses the concept. What has been realized is that in countries like the Sudan where the central government is hard pressed for funds, the only realistic solution for operation and maintenance is to develop a system which puts the responsibility on the beneficiaries to operate and maintain their own water supplies.

TECHNOLOGY SELECTION FOR LESOTHO'S RURAL WATER SUPPLY PROGRAMME

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Introduction

Lesotho is a small mountainous country with a population of 1.6 million. It is landlocked and completely surrounded by the Republic of South Africa. The total area of the country is 30,350 square kilometres of which two-thirds is high mountains and hills with elevations ranging from 1500 to 3500 metres. Due to its varying topography the country is divided into three characteristic regions, namely the lowlands, the foothills, and the mountains.

Significant development of the rural water supply subsector in Lesotho only occurred after independence in 1967. Prior to this there was no rural coverage. The new government gave top priority to the rapid installation of new water supply systems and embarked on a campaign inviting villages to undertake joint ventures. The villagers were to collect and contribute some funds to the Government and provide free unskilled labour, while the government for its part would top up the funds to cover the capital costs and provide the necessary technical expertise.

With limited technical and institutional capacity and experience, the Government installed several rural water systems. The technology was chosen on the basis of simplicity of installation and installation time. The technologies selected included windmill systems, polyethylene pipe and the use of corrugated iron tanks for storage. These systems collapsed quickly as the windmill systems were inappropriate, the polyethelene pipe was not suitable for the topography and the tanks rusted.

Having realized these problems, the Government in 1975 established the Village Water Supply Section (VWSS) in the Ministry of Rural Development and sought out external assistance to strengthen the institutional capabilities of the section. Swiss technical assistance was provided in 1978 and the Swiss

developed standards for planning, design and construction of rural water supply systems. The major objective was to reduce operation and maintenance costs and requirements.

Systems Type

The technology in use by VWSS includes four different water supply facilities. Depending on the availability of water sources and the population size of the given village(s), the system is chosen on the basis of its operation and maintenance requirements. The preferred order of preference is:

1. Waterpoint (Spring protection): This facility comprises a spring collection completely sealed against direct human and animal pollution and a collection pipeline (1 to 2 pipe lengths of 6 metre length) leading to a storage tank which feeds a public standpost. The system is most common in the mountain areas where springs are readily available and are in close proximity to the village (average distance for people to walk is 300 metres) and population sizes are small (ranging from 50-200 people). Per capita cost of construction is about U.S. 8.00 in 1990 prices. Operation and maintenance requirements are almost zero as all that is required is an occasional flushing of the system. However, if leakage of the spring catchment occurs this may require recapturing the spring and reconstruction. This happens very rarely and is not really a major concern.
2. Gravity system: This system is an expansion of a waterpoint. It often includes multiple spring protection, several storage and distribution tanks, a distribution network and multiple public standposts. It has effectively no running costs and requires a minimum of maintenance as the quality of the structures is high and durable. However, it does demand a high level of management by the community, especially if several downstream villages are connected. The cost of maintenance is often not a financial one but rather requires a large input of community participation for regular inspection and preventative maintenance.
3. Handpump system: This is the third option where springs are not available. It is less expensive, having a per capita cost of US$ 16.00 as compared to a power-pumping system which costs US$

32.00 per capita (1990 prices). Also, it provides flexibility in that when one pump stops functioning, others are still available for use. Concentrated efforts to install this system began in 1982 and now there are over 2,000 handpumps installed. Initially, the pumps were the American made Moyno largely because the programme was supported by USAID. Recently, South African Monos have been installed. Fortunately, as both pumps are progressive cavity with a rotor and stator they have interchangeable major components. VWSS has standardized on the Moyno pump although the Mono is preferred because of the ease of availability of spare parts. Neither the Moyno nor Mono are VLOM as they require special skills and equipment to repair.

The VWSS has realized the heavy maintenance requirements for handpumps and has adopted the following maintenance strategy.

- Although the villagers are not able to carry out actual repairs, they have the responsibility for reporting to the VWSS pump breakdowns and must ensure the proper use of the handpump (i.e. keeping pump surroundings clean and preventing children from playing with the pump).
- VWSS has overall responsibility for maintenance and stocks spare parts and maintains an adequate level of trained maintenance staff.
- The VWSS is striving to get private sector involvement in maintenance to the maximum extent possible.
- VWSS continues to implement a system of cost recovery which at this stage aims to recover 50% of the direct costs of maintenance.

4. Power pumping system: It is VWSS policy to avoid power pumping and windmills whenever possible. These systems are very few in number (no more than 10% of the total VWSS existing systems) and the experience so far is that they breakdown frequently and have high running costs.

Power pumps require a high level of organizational capacity for collecting the needed cash contributions and a more complex financial accounting by the villagers.

Standardization

Village Water Supply Section standards for level of service, design and construction of structures, choice of equipment and construction materials have all been developed in order to minimize operation and maintenance even if these initially require high capital investment costs.

The overall standards of service are designed to meet the people's needs for 10-15 years without requiring a major expansion of works.

Gravity systems are designed for 30 litres per capita consumption, a maximum walking distance of 150 metres to the nearest public standpost and a maximum of 150 people per standpost. The VWSS only installs public standposts and discourages the installation of private (yard or house connection) taps. Handpumps are designed to serve 75-100 people per handpump. They are located within a 200 metre-radius around the village.

These design standards were developed to help overcome operation and maintenance problems and include the requirement that piped water systems should not connect an excess number of villages. However, when this is unavoidable every effort is taken to provide each village with individual distribution chambers and separate main distribution lines.

The Village Water Supply Section enforces a very high quality of construction and workmanship. Standards are well elaborated for construction masons, foremen and supervisors through construction manuals. Standard plans have been prepared for all structures such as storage tanks, siltboxes, valve chambers, public standposts and handpump slabs.

The Village Water Supply Section installs basically one type of handpump (Moyno or Mono). In addition the Section uses only galvanized iron piping for its pipelines and pump riser mains. This is a result of the ruggedness and rocky terrain of Lesotho. No exceptions are made simply to avoid problems

of maintaining a variety of spare parts and fittings. All structures are either of stone or brick masonry work.

Conclusion

Gravity water systems which require the least degree of operation and maintenance are the primary technology choice in Lesotho. Where this is not possible handpumps are the second option. When handpumps are used the VWSS undertakes to organize, with community support an adequate operation and maintenance system and strives to recover 50 percent of the costs of this maintenance. Power pumping systems are avoided if at all possible as they require a high level of village organization, management and financial organization.

COMMUNITY MANAGEMENT OF RURAL WATER SUPPLIES BY THE GHANA WATER AND SEWERAGE CORPORATION

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Introduction

Ghana is located in West Africa with a population estimated to be about 15 million of which around 70% is rural. Water supply coverage for the rural population is estimated to be 40 percent and for sanitation coverage is about 16 percent.

Water supply programmes have, in the past, favoured urban supplies as is attested to by a 90% coverage. The rural water sector has benefited from two large borehole projects, 3,000 boreholes in southern Ghana with German support, and a programme which constructed 2,600 boreholes with Canadian International Development Agency (CIDA) support in the upper regions.

The present rural water supply coverage of about 54% in the upper region of Ghana is a result of the CIDA/GWSC (Ghana Water and Sewerage Corporation) water programme which started in 1974. The aim of the programme was to provide potable water supplies which will ultimately improve the health of an estimated 1.2 million people.

Initially when the programme was started, community involvement regarding the choice of technology and the location of the boreholes was a low priority; so many of the efforts to improve the supply in the early stages concentrated on the technical aspects with little input from social organizations. The concept of cost recovery was also neglected. The result was a system with a poor operation and maintenance performance record.

The Ghana Water and Sewerage Corporation (GWSC) maintenance tariff system is currently operating satisfactorily with support from CIDA. The down time for a breakdown rarely exceeds three

weeks. Spare parts are available, although it occasionally takes up to six months to deliver them. Local GWSC Personnel are capable of handling most maintenance situations.

The real problem lies with GWSC's weak financial base for rural water supplies, as the collectible tariff is grossly inadequate to meet operation and maintenance costs. This paper reviews the major constraints to effective operation and maintenance and describes the strategy which has been adopted for community management.

Major Constraints

In the early stages of the programme the users had no input into the choice of technology or the location of water points and this constituted one of the major problems. Also, some of the wells were drilled during the rainy season when the water tables were high, and these wells have either gone dry or are yielding below expectations. These factors combined led to 5% of the wells being either out of use or very low yielding and have resulted in an understandable reluctance by the people to pay.

There has also been a search for a suitable handpump leading to the introduction of over 15 different types of pumps since 1974 which has further constrained the villagers level of involvement in maintenance and operation.

Efforts are now being made to reverse the situation. A massive water-health education programme has been on-going for the last four years to raise the awareness of the users by instilling a sense of ownership and care for water points and pointing out the benefits of potable water. The object is to demonstrate the health risks of using polluted water sources.

There are also well advanced plans to redevelop wells that have been low yielding due to either encrustation or silting. A community management pilot project was also established in parallel with the water-health education programme to determine the willingness and ability of the users to assume management responsibilities for their water points.

A New Strategy for Community Management

Experience gathered from the GWSC based maintenance tariff system, indicates a continuing heavy requirement for external financial support for operation and maintenance because the users are unable to meet tariff obligations. In an attempt to make the beneficiaries partners rather than just recipients of the water service, the Bolgatanga community management project was established in 1988. The project is funded by the Canadian International Development Agency (CIDA), and executed by the World Bank/UNDP Water and Sanitation Programme, GWSC and other local agencies. The project is designed to ascertain if communities are willing and able to assume management responsibilities for their water supply points with tariff collection being an important element.

One of the tasks of the project is to transfer management skills to user communities and to develop strategies that will enhance a smooth transfer of knowledge and skills at both institutional and community levels. The existing social-cultural values of the people are considered to be very important. The approach therefore allows for ideas to originate from the community through dialogue during regular meetings. These ideas are used as the basis for training the water and sanitation management committee (WASAMC). This strategy is aimed at maximising community participation and enhancing capability in assuming management and maintenance responsibilities.

Uniformity in approach and adherence to some traditional norms contributes immensely to winning community admiration and support. Sound financial management has been identified as one essential ingredient for the success of a sustainable programme. Although lack of money has often been cited as a drawback to development, it is really poor management of funds which cripples most development efforts. A simple accounting and banking system has been instituted by the communities with the assistance of the project to eliminate the misuse of funds collected by community members.

A management structure that fits into the existing local institutional structure has been established, which aims to involve all community members. The WASAMC which is the main community based

action group responsible for the day to day management of the water and sanitation facility comprises seven members of whom at least three are women. Women in the project area have demonstrated a high sense of responsibility by leading many committees. They are also the main contributors to the community pump maintenance fund.

Training programmes have been organised for village based technical personnel and for the core committee members on basic repair and management skills in order to prepare them to better undertake maintenance and repair activities. This strategy is not without its problem and two major ones, one community based and the other institutional have arisen.

In the communities there are conflicts and disagreements within the committees. Some of these originate from long standing family disputes but most are due to poor communication. In some instances there are financial management conflicts between the committee and the community due to poor record keeping. This problem is due to the low literacy level in the rural areas and adult literacy and planned management training will hopefully reduce these problems.

The institutional problems are rather more difficult to define. Clear roles for partner agencies and the communities have not been established with respect to operations and maintenance. It is not clear if the community is expected to undertake all operation and maintenance responsibilities. Spare parts supply and distribution is a pre-requisite for community management. It is not yet known whether GWSC will encourage private sector involvement and whether the private sector will be interested in the supply and distribution of spare parts since to this point this has been the sole responsibility of GWSC. Another critical issue is whether the inter-agency approach will survive. Some departments in government are not in favour of this approach and instead support narrow departmental interests. This can have adverse effects on human and material allocations to the project. Commitment of all agencies therefore depends on government commitment and support for such a programme. All these issues need to be addressed before sound community based management can be instituted.

Achievements

In spite of these problems some real success has been attained. Progress made has been tremendous particularly in the area of popular participation and fund mobilisation for maintenance. People who formerly did not pay tariffs now pay more into the community accounts. Communities are able to carry out routine maintenance and repairs on their pumps and to assume responsibility for preventative care. Generally there are improving signs of the willingness and ability by communities to manage their own water supply and the prognosis for the future is very favourable.

FINANCING OPERATION AND MAINTENANCE OF WATER SUPPLY SYSTEMS IN ZAMBIA AND MALAWI

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Lusaka, Zambia

Introduction

The last ten years (1981-1990) has witnessed the significant development of water supply for the urban and rural populations in Zambia and Malawi. The benefits of improved services have been, in many cases, short-lived as the facilities quickly failed to function. One of the major reasons why services could not be sustained is the generally poor performance of operation and maintenance. A contributing factor is inadequate funding.

This paper discusses how Zambia, and Malawi are approaching the problem of improving the funding of operation and maintenance (O & M) of water supply facilities. Examples will be drawn from the urban water supply sector in Zambia, and from the rural water supply sector in Malawi.

Sector Objectives and Institutional Framework

The objectives of the water supply sector in both Zambia and Malawi echo the goal of the International Drinking Water Supply and Sanitation Decade (IDWSSD). Paraphrased, the objectives can be stated as "to ensure permanent supplies of water of acceptable quantity and quality to as many users as possible." The underlying justification is improved health and economic development.

There are many similarities between Zambia and Malawi with respect to the institutional framework. In both countries governments have the prime responsibility for providing water supplies to the urban and rural populations. These responsibilities are carried out through government technical departments, statutory bodies or parastatal organisations. The government ministries dealing with water (or natural resources), health, local government, and social services are the major sector organisations.

In Zambia the Department of Water Affairs has the major responsibility, among others, for water supplies to rural areas and to small townships. In Malawi the corresponding institution is the Water Department. Large urban centres have their own departments responsible for providing water and sanitation services. In Malawi the two largest urban centres of Lilongwe and Blantyre have autonomous statutory boards responsible for water supply services. In Zambia, the Lusaka Water and Sewerage Company, a subsidiary company of Lusaka Urban District Council, has full responsibility for providing water and sanitation services to the capital city which has about one million people. Other large towns are in the process of establishing organizations similar to the one in Lusaka.

Support for the Sector

Several external support agencies (ESA's) provide investment support and technical assistance to the water sector in Zambia and Malawi. These include: multi-lateral agencies such as the World Bank, African Development Bank, UNDP, WHO, and UNICEF; bilateral agencies (for example NORAD, USAID, DANIDA, GTZ/KfW, Japan, Netherlands Government); non-governmental organizations such as Lutheran World Federation, Save the Children, Christian Services Committee, and Africare. Bilateral and UN agencies have provided the bulk of support for rural water supplies in Zambia and Malawi.

Coverage and Service Levels

In Zambia it is estimated that about 60 per cent of the total population have access to safe water supplies. In the urban centres (about 48 per cent of total population) more than 75 per cent of the population are served with water supplies through house connections and individual or communal standposts. In the rural areas some 40 per cent of the population has reasonable access to safe water supplies provided through boreholes, protected dug wells, and piped water schemes.

In Malawi current estimates indicate that some 4.5 million rural people (about 64 per cent of the rural population) are without improved water supplies. In the urban centres, where 14 per cent of the total population of Malawi live, about 75 per cent of the urban population is provided with safe water supplies.

Major Constraints to Operation and Maintenance

In the urban water sector in Zambia all operation and maintenance of water schemes is the responsibility of the technical departments of the city or township authorities. In the case of Lusaka, the Water and Sewerage Company has the mandate to provide water and sanitation services to the one million inhabitants, about 50 per cent of whom live in the periurban zones. In the rural areas, the Department of Water Affairs and rural district councils have the major responsibility.

In Malawi all maintenance of small townships and rural water supplies is the responsibility of the Water Department. Thus all boreholes, dug wells, township schemes, and some 55 gravity-fed piped water schemes are under the responsibility of central government. The statutory boards for Lilongwe and Blantyre have maintenance responsibilities for their schemes.

The main constraints to effective operation and maintenance include inadequate funds (mainly from government allocations and user contributions), shortage of adequately skilled manpower, inappropriate technology and institutional weaknesses of sector organizations.

The shortage of funds for capital development and for operation and maintenance has been caused by inadequate financial allocations from central government and the poor financial performance of sector organizations. Contributing factors include high levels of non-revenue water; low levels of revenue collection; unrealistic water tariff structures exacerbated by the slow process of tariff reviews and adjustments; and poor maintenance of installations. In addition, levels of financial contributions from the users have not been set to realistically reflect either the real value of the services or the user's willingness to pay for the services provided.

In the rural areas, whether in Zambia or Malawi, there are many examples indicating that the technology adopted for some of the installations can only be maintained by central government. The target communities have neither the skills nor financial resources to manage the installations. The technology being used is beyond the technological capabilities of the benefiting communities.

Solution Strategies

Problems of financing O & M of water supply facilities exist in varying degrees in the urban and rural water supply sector in Zambia and Malawi. Solution strategies adopted to address the major constraints reflect differences in levels of service provided, the extent of coverage, technology in use, sources of funding of the project, and institutional weaknesses of sector organizations. These strategies are discussed below, firstly for urban water supply in Lusaka, Zambia, and secondly for rural water supply in Malawi.

Example from Lusaka

Following a series of institutional assessments carried out between 1977 and 1984 with technical assistance from the Federal Republic of Germany, Lusaka set up a framework for a long-term solution to its operational problems. A comprehensive approach was adopted which would eventually set the basis for more effective coverage of water services to the inhabitants, and enhance sustainability of installed facilities. The city authorities therefore began to put into effect a comprehensive development plan that included not only physical rehabilitation and extension of the water system, but also human resources development, and institutional reorganization that has led to the establishment of an autonomous Lusaka Water and Sewerage Company.

An important aspect of the institutional development plan was the drawing up and implementation of a man-power development plan. It provides for group and individual training programmes which are meant to improve group and individual management skills and upgrade technical, professional and supervisory levels of competency in the organization.

The city has been divided into service areas, and different strategies are being implemented so as to provide supply levels which are appropriate to each service area. In the metropolitan area, with conventional multiple tap house connections, there is more effort aimed at improving metering, reducing

water wastage, and improving revenue collection. A combination of user education, and disconnection policy is used to encourage timely and complete settlement of water bills.

A strategy adopted for the low cost high density periurban areas is the development of "Satellite Water Schemes". These consist of a borehole, elevated storage tank and distribution mains serving individual or communal standpipes. These water schemes will be operated as separate supply units where the source will be maintained by the company while the user community will be responsible for operation and maintenance. Plans are underway to develop procedures and activities to promote active involvement of the users in the planning, implementation and management of the satellite water schemes. Such an approach would, in due course, lead to self-financing sustainable schemes in the periurban zones.

Example from Malawi

Since the beginning of the Decade Malawi has had some notable successes in implementing rural water supply programmes involving groundwater and gravity fed piped water schemes. Through the Piped Supplies for Small Communities (PSSC) programme, funded by the Netherlands Government through the International Water and Sanitation Centre (IRC) some community based management approaches have been developed and demonstrated at several sites including rural and periurban areas.

Community participation has been promoted during the planning, implementation and management of the water schemes. Efforts were directed at maximazing the involvement of communities, especially women, in decision making, as a basis for sustainable development. In addition a sense of ownership was built up with a view to improving responsiblity in operation and maintenance. The communities were encouraged to appreciate that they were in partnership with the development agency. The multi-disciplinary nature (water, health, social development) of project teams enabled more open and active participation by the communities.

Community organizations (water or tap committees) were assisted with training in simple accounting and financial management. They set up their regulatory mechanisms for utilising the funds

collected from the communities. Agreements were also drawn up between the development authority and the communities on division of responsibilities. For piped water schemes, for example, there was agreement that the Water Department would carry out repairs, but the spares would be provided by the communities.

Greater emphasis was placed on sharing information and experiences through workshops and study tours at a national level between sector organizations and projects and at regional level with related projects from neighbouring countries.

Results Achieved

The implementation of the appropriate strategies for the provision of water supply services already shows promising results. In Lusaka as a result of improvements in billing, collection and rehabilitations in the water systems, actual water revenue increased tenfold between 1982 and 1987, and still continues to increase although at a slower rate.

The existence of a clearly defined water development plan for Lusaka with short-term, medium-term and long-term goals, has begun to attract ESA support. Lusaka Water and Sewerage Company is implementing a US $36 million rehabilitation programme with funding from the African Development Bank.

The reorganization of water supply services in Lusaka is being emulated by other large urban centres in Zambia. Thus Lusaka is providing a practical, viable model for the sector.

In Malawi the approaches developed through the IRC supported Piped Supplies for Small Communities Project have found wider application in the rural water supply sector. Malawi has begun implementing a UNDP-funded project (MLW/88 - Support for Community-Based Management in the Rural Water Supply Sector) aimed at coordinating, and promoting community management of rural water supplies.

The information sharing activities, through workshops and seminars, have engendered a more comprehensive outlook to rural water projects. It is increasingly being appreciated that successful rural water projects involve a partnership between the development authority and the target community for all phases of a project. There is also open debate on how to ensure sustainability of water and sanitation facilities. Case studies have been undertaken which have yielded valuable insight regarding the basis for sustainability of some of the existing community water supplies.

Conclusions

Experiences from both the urban and rural water supply sectors in Malawi and Zambia show that solutions to problems of funding operation and maintenance can best be solved in a framework involving improvements in several areas including community participation, institutional set-up, human resources development and technology. These factors all require resources in terms of funds, time and skills. Thus a more comprehensive approach for addressing O & M problems is the basic model for resources coverage. Operations and maintenance should be viewed as one of the important and essential elements of sustainable water supply development if systems are to operate over the long term.

OPERATIONS AND MAINTENANCE OF RURAL WATER SYSTEMS IN ZAIRE

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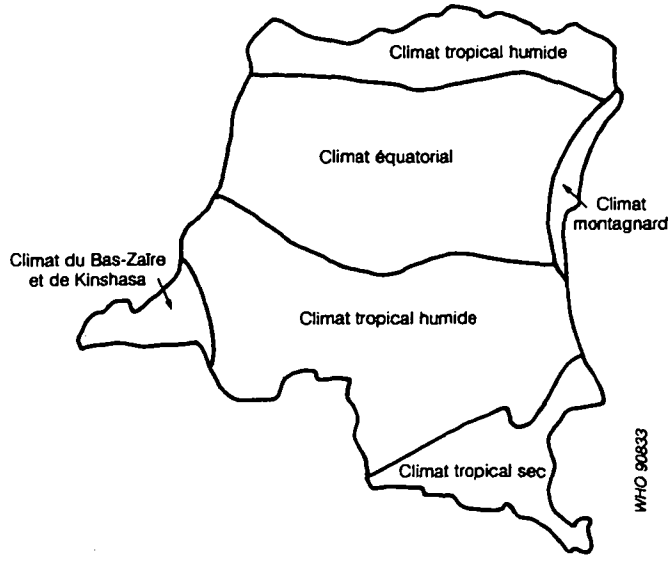
Introduction

Zaire, located on both sides of the equator between 50° 20' latitude north and 13° 27' latitude south and 12° 31' longitude west and 31° 16' longitude east, is the largest country in Central Africa.

Zaire, stretching over 2,345,409 km^2, has a narrow window on the Atlantic Ocean to the west which coincides with the mouth of the Zaire River. It is bordered to the northwest by the Congo, to the north by the Central African Republic, to the northeast by Sudan, to the east by Uganda, Rwanda, Burundi and Tanzania, to the South by Zambia and to the southwest by Angola.

FIGURE 1
Climats du Zaïre



The central basin is bordered on all sides by areas of high relief. In the north, plateaus range between 600-800 m and in the south, between 1,000-2,000 m. To the east, the relief is created by the collapse of the occidental Rift Valley and by massive volcanoes reaching 4,500-5,000 m.

The geographic setting of Zaire between 5° latitude north and 13° latitude south and its distance from the sea in the middle of a vast continent determines the basic characteristics of the Zairian climate. There are four distinguishable climates (Figure I).

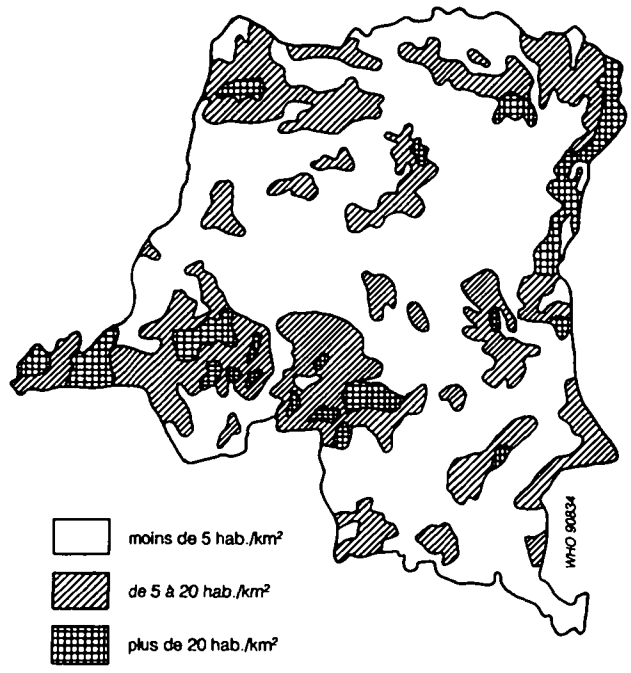
The equatorial climate is hot and humid. Annual rainfall everywhere is greater than 1,500 mm and on rare occasions exceeds 2,200 mm. Temperatures vary little and humidity is permanently above 85 percent.

The humid tropical climate extends on both sides of the equator. Annual rainfall is between 1,200 mm and 1,800 mm and nowhere do temperature ranges exceed 3°C. Humidity is between 70 and 85 percent.

The dry tropical climate is characterized by an annual rainfall which is between 1,200 mm and 1,500 mm, temperatures variations of up to 8°C, and low atmospheric temperatures and humidities.

The mountain climate is characterized by declining temperatures at increasing altitudes. At 2,000 metres, temperatures are between 15-16°C. At 4,500 m, at a temperature of 0°C, only mosses and lichens are able to survive

FIGURE II
Population rurale du Zaïre



The population of Zaire is presently estimated to be 35 million; 65 per cent of whom live in rural areas. The growth rate is estimated to be 2.7 percent; however, the rural growth rate is 2 percent due to rural out-migration and to a very high child mortality. Population density is around 13 inhabitants per km^2 (Figure II).

Water Supply

The tectonic movements which affected the African continent resulted in the creation of a basin in the center of Zaire which drains the entire country. This basin is underlain by porous rock capable of retaining subterranean water and forms a natural underground water reservoir.

Generous rainfall, substantial water flows, and the geological structure of the country are such that Zaire does not face a shortage of water resources for domestic use. Problems are related rather to water quality and its availability for domestic use.

Public health problems in Zaire are complex and numerous, including the prevalence of diseases such as malaria, diarrhoeal and respiratory diseases, infectious diseases (tuberculosis and leprosy), and parasitic diseases (bilharziasis and tripanosomiasis). Measles is especially devastating among small children.

Recent health statistics revealed a very high number of diseases directly or indirectly related to water quality and poor sanitary conditions.

"Health for all by the year 2,000" is the objective adopted by the Executive Council to remedy this situation. "Primary Health Care" is the strategy which will enable Zaire to achieve this objective.

The country has been divided into 306 rural and urban health zones; 100 of these zones are already functioning. A health zone consists of:

- a reference hospital for treatment of diseases which cannot be treated at health centers.
- about 20 health centers, each serving about 5,000 people in rural zones and 10,000 people in urban zones.

- development committees led by volunteers chosen by the community.

Rural Water Supply

Activities to provide potable water to rural inhabitants of Zaire began around 1948 when "le Fonds du Bien-être Indigène" (FBI) was created in order to implement "all activities able to enhance material and moral development of "la Société Traditionnelle Indigiène" of the Belgian Congo.

This agency pursued such activities until 1964, although most water construction projects were discontinued in 1959. The FBI capped and improved 1,355 springs, installed 1,634 hand pumps and constructed 138 km of water adductions thereby serving 771,372 people. In addition, the FBI financed 385 spring cappings, 441 hand pumps and 5 small water adductions. During this period, the FBI was directly responsible for maintaining water systems. Later, beneficiaries were given this responsibility. However, they were given no preliminary training by the technical division of the agency and thus were unprepared to carry out this operation and maintenance task.

The financing of maintenance costs were assured by a "water tax" included in the income tax. With the withdrawal of the FBI there was no longer any agency to maintain these installations and since the local populations were unable to do so, the systems deteriorated. There were a few scattered efforts, supported by religious, non-governmental organizations, and REGIDESO (the national water company), to continue installation and maintenance of potable water systems.

In 1977, the Department of Rural Development resumed the activities of the FBI including provision of potable water to rural zones.

In 1978, in reaction to endemic diseases and drought in some areas of eastern and western Zaire, rural water brigades were created with financial assistance from UNICEF.

Strategies and objectives were only vaguely defined at this time. It was not until the 1980s with the advent of the International Decade for Water Supply and Sanitation that objectives to reach 70 percent

of the urban population and 35 percent of the rural population were set. The percentage of the latter was increased to 50 percent under the most recent seven year plan.

The strategy to achieve the above objectives was not defined until the middle of the decade during the National Symposium on Rural Water and Sanitation organized in 1985 by the National Action Committee for Water Supply and Sanitation. This strategy was revised in 1987.

The past decade has witnessed an increase in potable water service to 20.5 percent; this figure was realized in late 1989, whereas at the end of 1987, it was 16.3 percent. Implementation of water system activities received an impetus in early 1985 due to generous financial inputs mostly from USAID and to the creation of the National Rural Water Service (SNHR). SNHR was established to complement activities of the REGIDESO (Water Supply Agency) and non-governmental organizations (NGOs).

To date, 5,068 springs have been capped 1,115 wells drilled and equipped with handpumps and 80 water adductions, (90 percent gravity fed) constructed. These installations provide potable water to nearly 4.1 million people.

Funding for the implementation of the rural potable water supply programme in Zaire is assured by a combination of the following agencies.

- The government of Zaire
- The beneficiaries
- Bilateral cooperation:
- United States Agency for International Development (USAID),
- Belgian Cooperation
- Japanese Agency for International Cooperation (JICA)
- Multilateral cooperation:
- United Nations Children's Fund (UNICEF)
- United Nations Development Program (UNDP)

- African Bank for Development (BAD)
- European Funds for Development (FED)

Community Participation

In Zaire, community participation is considered to be the means by which communities which are going to benefit from developmental assistance actively participate in all aspects of planning, implementation, and evaluation to solve problems which they have identified.

Zaire believes that active participation allows communities to better solve problems and provides them with the necessary means to continue solving problems with a decreasing dependency on outside assistance.

The experience in Zaire is that projects are only successful if the community served participates actively in project design and implementation and that projects are only sustainable if inputs, motivations and activities are related to resources already existing in the community.

Communities must participate in every aspect of project development including:

- analysis of actual situation
- identification of problems
- analysis of targeted problem
- choice of action plan to solve targeted problem
- design of plan of action
- implementation
- follow up and evaluation.

Community participation means entirely entrusting the management of water systems to the benefitting community.

The various agencies involved seek to motivate the community and instill a sense of self-management with activities conducted through existing community organizations. Several indicators are used to measure community participation:

- Acquisition and transportation of construction materials (sand, stone, gravel, etc.)
- Financial contribution of beneficiaries in relation to village income and required operating costs
- Self-organization for operation and maintenance of water systems
- Participation in construction
- Logistical support of technical team at the construction site
- Establishment of a water committee.

Operations and Maintenance of Water Systems

The WASH (Water and Sanitation for Health) Project recently assisted the SNHR in defining an operations and maintenance programme for rural water systems. This strategy has now been implemented in an organized fashion in rural areas.

A nation wide forum regrouping all parties concerned met under the auspices of the National Action Committee for Water and Sanitation to formulate guiding principles for a common national approach to operations and maintenance of water systems. After much discussion, the group was able to agree on the following principles:

- responsibility for maintaining water supply systems rests with the community;
- a financial contribution prior to construction is a key indicator of the local community's willingness to assume responsibility for maintenance of water systems;
- community participation in the design, construction, and operations of potable water systems is essential to ensure sustainability

The following are currently involved in the operation and maintenance process:

- Technical service
- Beneficiaries

1) The technical service is responsible for animating and sensitizing the villagers through development committees; for construction and follow-up of water systems; for ensuring proper functioning of systems which may require maintenance beyond the competence of the local repairman; and for establishing a reliable supply chain of spare parts.

2) The beneficiaries are responsible for establishing a committee to manage water systems; maintaining cleanliness of water source, designating individuals to receive technical training, appointing person to be responsible for maintenance, and assuming any recurrent maintenance costs.

A comprehensive "programme d'animation", taking into account the specificity of the most common systems in a given region (province), must be developed in order to accomplish the above.

One example of the programme which is worth describing is the installation of pumps.

In the south-western Lualaba region, where there exists an intensive programme of drilling and spring capping, the following procedure is used:

Each village slated for the installation of one or more pumps or spring cappings receives the visit of an animator who organizes a series of 6 preliminary small group meetings with the villagers.

1) Informal Presentation Meeting: The animator notes the problems and importance of water as well as possible solutions.

2) Formal Presentation Meeting: He/she explains the different options and probable costs.

3) Acceptance Meeting: He/she focuses on the necessity of contributions from the villagers and on the choice and placement of the pump.

4) Committee Constitution Meeting: Discussions are held concerning the role of committee members, the committee's nature as a voluntary organization, elections, and the contract to be signed between the technical agent and the village.

5) Construction Meeting: The animator reiterates the villagers obligations; ensures that the basic maintenance kit (containing high mortality spare parts) has been purchased; describes briefly drilling and pump installation procedures including a few comments on local maintenance. Once the basic maintenance kit has been purchased (Z20,000 or $40 per household), the animator advises the village of the probable drilling period and informs the technical team.

Three months following the installation of the pump, the animator returns to the village to ensure that the pump is functioning correctly and that it is being used properly. The animator also checks to be certain that the designated caretaker is maintaining the pump as instructed. This inspection visit is undertaken in collaboration with the health zone staff.

The animator also examines financial records.

In addition to animation activities which take place before, during and after installation of the pump, training of different levels of personnel is also undertaken:

- Regionally: training of animators
- Locally: training of artisan-repairmen, committee members, storekeepers, treasury clerks

Another important point concerns the spare parts supply chain (basic tools and maintenance kits). The tools and spare parts are distributed by the National Headquarters to the Rural Water Stations (Regional), Rural Water Station: - Health Zone, Religious Organizations, NGO or Other Community Organizations and to Health Centers or other NGO and to Artisans and Repairmen.

Another example of the programme and process is a gravity fed adduction. Since 1978, several water systems have been established in North Eastern Zaire, North and South Kivu, and many other

systems are now being constructed. To date, these systems continue to provide water for local communities without the technical assistance of the agency which installed them, i.e. SNHR (the National Rural Water Agency) and various NGOS. How can the maintenance of these systems be organized? The response to this question is found in the procedures adopted by SNHR to ensure the operation and maintenance of these installations.

During the design of the water system, the community actively participates via the Development Committee which exists in the village or is created by the health zone or other parties concerned. At this time two or three people are appointed by the community to work with SNHR in the installation of the adduction system. They participate in the entire construction phase and are familiar with all systems. These individuals, often volunteers, are trained to repair leaks and replace faucets. Generally, the villagers all contribute to cover the cost of a breakdown which is repaired by the local repairman. The repairman often has his own water supply point in his yard and is thus motivated to promptly repair breakdowns. This is often also true of the village chief and other key persons.

The operation and maintenance system in effect is estimated to be approximately 90 percent satisfactory as evidenced by cleanliness of water supply sources, number of pumps functioning, motivation and promptness of villagers in contributing to maintenance costs, villagers' social organizations and needs expressed by other villages.

However, despite these achievements, there are specific constraints to full success. These include:

- Lack of attention to community priorities
- Inadequate funds allocated exclusively to activities related to the maintenance of systems
- Very rapid fluctuation in price of spare parts, and handpumps
- Pursuit of Project objectives within a fixed period while ignoring the time necessary to change the beneficiaries traditional attitudes and practices. This is very often due to a lack of communication between the technical service and the animators.

Conclusions

In Zaire, the strategy and system for maintenance of gravity fed adductions and spring cappings works well; however, for pump installations it is still too early to tell. Furthermore, it has been realized that the overall success of rural water projects depends less on the technical success of water installations and more on the absolute necessity of operations and maintenance of water systems being assumed by the beneficiaries themselves and this is being increasingly emphasizing in projects.

Future activities to enhance the operations and maintenance capacity are to:

- Interest local enterprises in the production of handpumps and spare parts adapted to rural conditions in Zaire by encouraging informal sector small entrepreneurs interested in repairing pumps to expand
- Continue training animators, artisan-repairmen, development committee members and treasury clerks and
- Encourage external support agencies to fund the operation and maintenance of water systems.

THE HANOI WATER SUPPLY PROGRAMME

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YME Group Finland

Introduction

The urban area of Hanoi City is approximately 48 km^2, with a population according to the census 1988 of 927 000 and a population density which varies from 78 p/ha to 1321 p/ha, (average 224 p/ha). Population forecasts and increases in the urban area are shown in Table I.

TABLE I

	1990	1995	2000	2010
Population (1000's)	990	1048	1120	1400
Urban area (ha)	4800	5615	7007	10199

The raw water source is a groundwater aquifer underlying the city. Iron and manganese are removal by aeration, sedimentation and rapid sand filtration and disinfection with liquid chlorine is the normal bacteriological treatment. There are 106 wells with a total capacity of 320 000 m^3/d. and 64 of these were constructed or rehabilitated by the Hanoi Water Supply Project. There are 8 major water plants, each with a capacity of 30 000 - 60 000 m^3/d and 10 small plants with a total production 55 000 m^3/d. The total capacity of the water plants is 375 000 m^3/d while the capacity of water plants, which were rehabilitated or constructed by the Project is in total 205 000 m^3/d.

The institutional structures for water supply and sanitation in Hanoi are very complex. Figure I presents the organization of the Hanoi water supply programme while in Figure II is depicted the organization of the Hanoi Water Supply Company (HWSCo). As can be seen from Figure II the Director of the HWSCo is directly responsible for almost every aspect of the operation of the facility.

Figure I

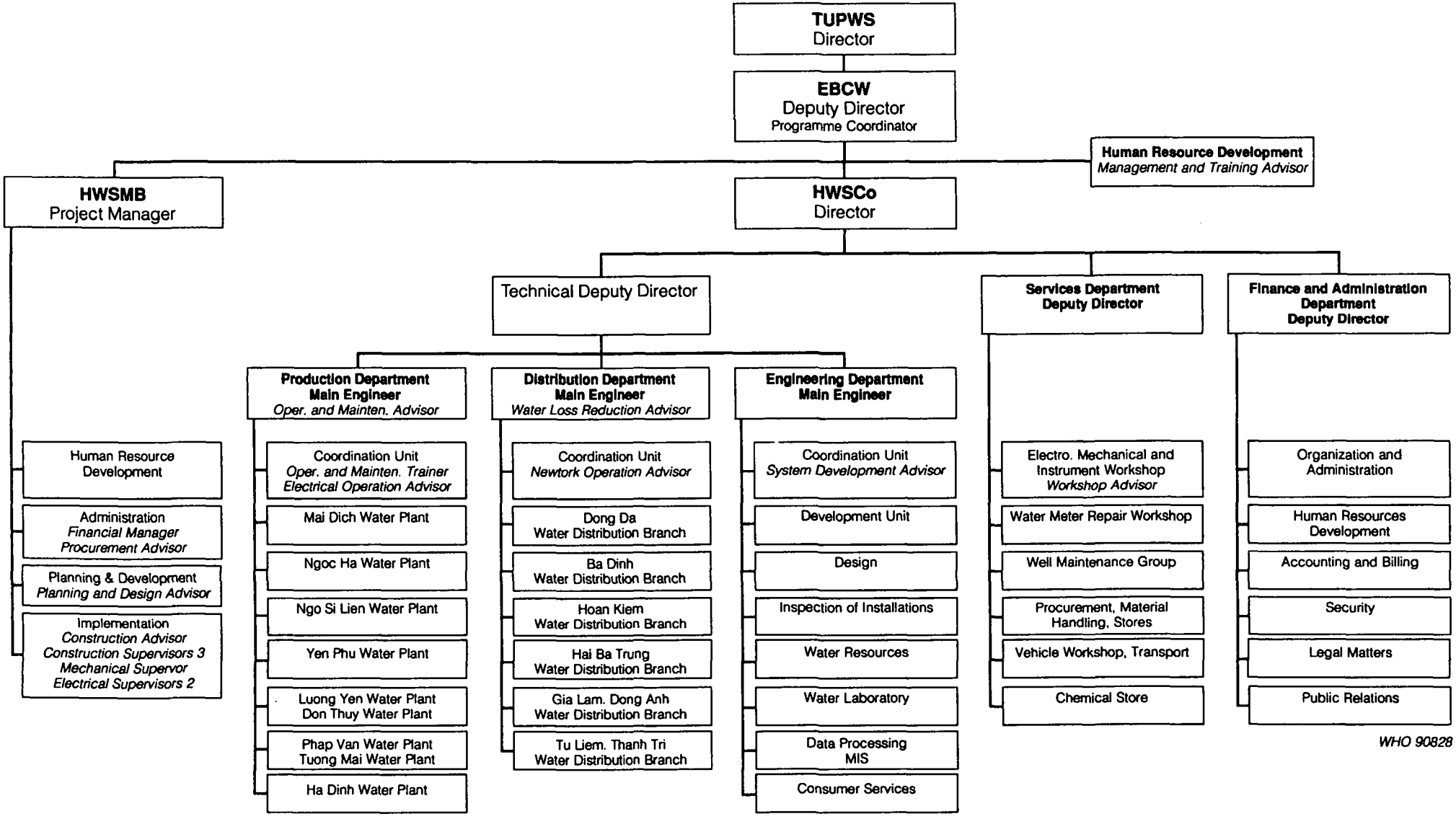
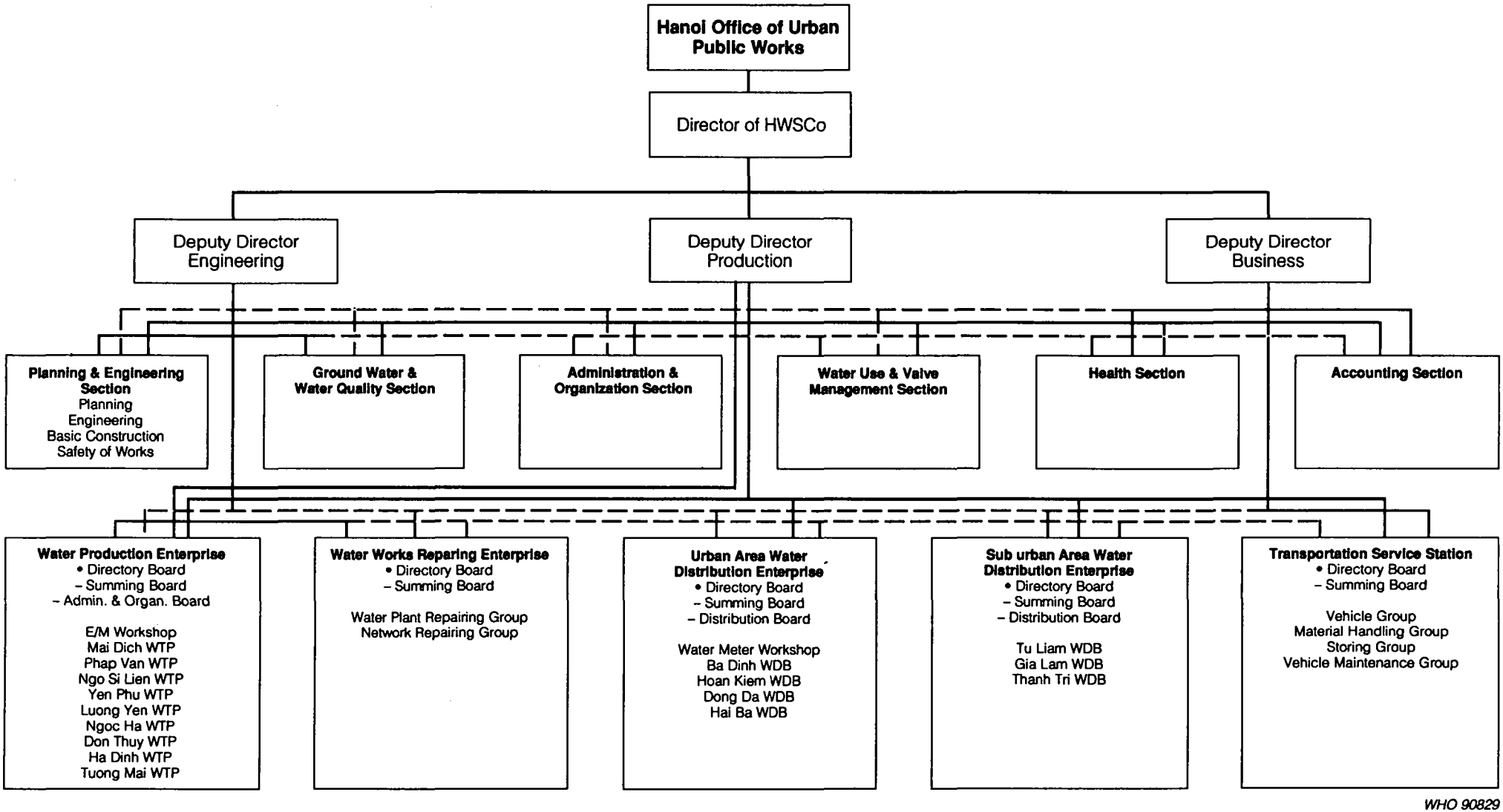

TUPWS
Director
EBCW
Deputy Director
Programme Coordinator
Human Resource Development
Management and Training Advisor
HWSMB
Project Manager
HWSCo
Director
Technical Deputy Director
Services Department
Deputy Director
Finance and Administration
Department
Deputy Director
Production Department
Main Engineer
Oper. and Mainten. Advisor
Distribution Department
Main Engineer
Water Loss Reduction Advisor
Engineering Department
Main Engineer
Human Resource
Development
Administration
Financial Manager
Procurement Advisor
Planning & Development
Planning and Design Advisor
Implementation
Construction Advisor
Construction Supervisors 3
Mechanical Supervor
Electrical Supervisors 2
Coordination Unit
Oper. and Mainten. Trainer
Electrical Operation Advisor
Mai Dich Water Plant
Ngoc Ha Water Plant
Ngo Si Lien Water Plant
Yen Phu Water Plant
Luong Yen Water Plant
Don Thuy Water Plant
Phap Van Water Plant
Tuong Mai Water Plant
Ha Dinh Water Plant
Coordination Unit
Newtork Operation Advisor
Dong Da
Water Distribution Branch
Ba Dinh
Water Distribution Branch
Hoan Kiem
Water Distribution Branch
Hai Ba Trung
Water Distribution Branch
Gia Lam. Dong Anh
Water Distribution Branch
Tu Liem. Thanh Tri
Water Distribution Branch
Coordination Unit
System Development Advisor
Development Unit
Design
Inspection of Installations
Water Resources
Water Laboratory
Data Processing
MIS
Consumer Services
Electro. Mechanical and
Instrument Workshop
Workshop Advisor
Water Meter Repair Workshop
Well Maintenance Group
Procurement, Material
Handling, Stores
Vehicle Workshop, Transport
Chemical Store
Organization and
Administration
Human Resources
Development
Accounting and Billing
Security
Legal Matters
Public Relations
WHO 90828

FIGURE II



WHO 90829

There is an obvious lack of middle level management responsible for the day to day running of the facilities.

Transportation and Urban Public Works Service (TUPWS) has overall responsibility for water supply as well as sanitation and sewerage in Hanoi City. It controls the following companies carrying out the relevant tasks in the sector:

- Hanoi Water Supply Company
- Sewage Company
- Sanitation Company
- Design Enterprise

Hanoi Water Supply Company (HWSCo) is responsible only for operation, maintenance and management of the water supply system for the urban area of Hanoi City. It has been heavily subsidized by the State and by the Hanoi People's Committee, but is now, according to recently established general policies, striving towards self financing operational status.

Sewage Company (SewCo) is responsible for operation and maintenance of the drainage and sewerage system. It depends totally on the budget allocations of the People's Committee of Hanoi, but also is planning to collect sufficient revenues to cover operational and maintenance expenses.

The Design Enterprise (DE) has grown up during the Hanoi Water Supply Project and is at present doing all the design work for distribution pipelines and house connections in the Project.

The Executive Board of City Waters (EBCW) is chaired by the Director of TUPWS and it controls and coordinates the programme implementation, management and operation of the water supply and sewerage systems.

The Government of Finland and the Government of Vietnam signed an agreement on the 11th of June, 1985 for the rehabilitation, upgrading and extension programme of the Water Supply System to the

City of Hanoi. Under the EBCW, the Hanoi Water Supply Management Board (HWSMB) is responsible for the implementation of the Programmes. The long-term goal of the Project was to:
"obtain, treat and deliver an adequate quantity of self financing, good quality, wholesome water efficiently and at least cost to the citizens, industry and other consumers of the city".

At the commencement of the first phase of the Hanoi Water Supply Project, in June 1985 the water supply situation in Hanoi was in a critical state The water supply system included 106 ground water wells, 8 major water plants and about 210 km of pipelines. The nominal production of water was about 290 000 m^3/d for the whole urban area. The existing water treatment plants and pumping stations were in urgent need of rehabilitation and the service level of water distribution was very low. The main problems of the network were excessive leakage and illegal connections. Over most of the service area the pressure in the network barely raised water to street surface level.

The initial phase of the project included:

- Preparation of a Water Master Plan.
- Construction of Project Office, Workshop and Housing Camp
- Facility Repair Programme (four existing water plants)
- Construction of two new Water Plants
- Construction of pipeline networks (raw water pipelines, transmission pipelines, distribution pipelines and house connections)

The total Finnish contribution to Phase I was 30 million USD. The Vietnamese contribution was in total 502,5 million Dong, and the actual cost 5,032 billion Dong. The high inflation rate affected the figures, and it is estimated, that the Vietnamese contribution at present value was about 22 billion Dong, or 5 million USD.

A second phase of the Hanoi Water Supply Project was started on July 1st, 1988 and is planned to end on 31st December, 1990. Its over-all long-term development objective is the creation of a self

financing public utility which will provide potable water efficiently and at least cost to the citizens, industry, and other consumers in the City of Hanoi. This Water Supply Company should operate without subsidies.

The immediate objectives of Phase II include four sub-projects:

- Water Plants: To increase the production capacity of the water plants to a total level of 374 000 m^3/d, from 304 000 m^3/d.
- Networks: Efficient transmission and distribution of increased quantities of treated water, improvement of service level with less interruptions in the distribution, improvement in users accessibility to water, increase in service pressure and improvement of water quality.
- Training for Operation and Maintenance: Training of staff so that they are capable of operating and maintaining the new and rehabilitated facilities without expatriate help.
- Technical and Economic Studies: Developing a new comprehensive Water Master Plan as a frame work for all key decisions concerning long term development of the water supply system.

The total Finnish contribution for the second phase of the Project is 26 mill. USD. The Vietnamese contribution according to the Project Document is 2.2 billion Dong. Inflation has affected the figures, and during the years 1989 and 1990 the Vietnamese contribution has been about 11 billion Dong annually. The total Vietnamese contribution for phase II is estimated in present value to be 6 million USD. A third phase of the project is currently being designed. Emphasis in this phase will be on improving the institutional capacity of the Hanoi Water Supply Company.

The responsible authorities for the programme are presented in Table II.

Table II

Responsible Authorities for the Hanoi Water Supply Project

Vietnamese Competent Authority	The People's Committee of Hanoi City
Finnish competent Authority	The Ministry for Foreign Affairs of Finland, represented by FINNIDA,
Vietnamese Implementing Agency:	The Transportation and Urban Public Works Service (TUPWS)
Finnish Executing Agency:	YME-Group

Institution Building and Training

To strengthen the institution building and training activities in the water supply sector a United Nations Development Programme (UNDP) financed parallel project was commenced in September 1987. A Management Board for the implementation of the project was established under the Hanoi People's Committee.

The project established a training centre, an instrument workshop, a water laboratory and a computer laboratory, made a proposal for the reorganization of HWSCo, a proposal for new water tariffs, and implemented training activities in collaboration with the Hanoi Water Supply Project. This project is due to end in June, 1990. Table III shows the responsible authorities for the Hanoi Water Supply Management Project.

TABLE III

Hanoi Water Supply Management Project

Vietnamese Competent Authority	The People's Committee of Hanoi City
Competent Authority	UNDP/OPS
Vietnamese Implementing Agency:	Management Board for Hanoi Water Supply Management
Consultant:	YME-Group

Major Constraints to Improving Operation and Maintenance

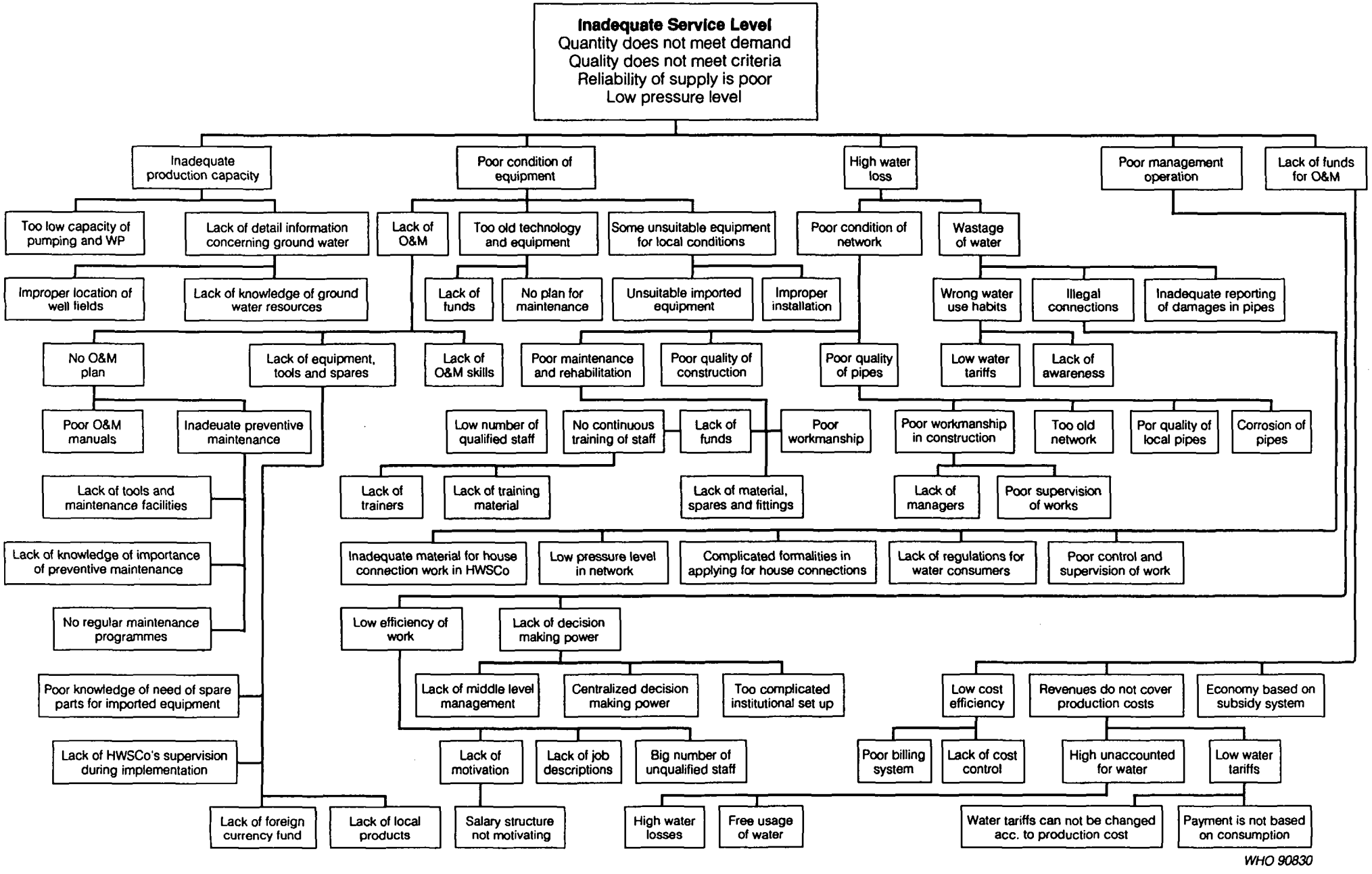
The first two phases of the Hanoi water supply project were clearly a "crash" programme and the main targets were to improve the critical situation in water supply. During the last few years the general economic philosophy in Vietnam is now orientated to a market economy, emphasizing the self-supporting principle in commercially oriented activities. This guideline is also applied to public enterprises, such as water supply companies and sanitation companies. The government also gives high priority to the improvement of urban water supply and sanitation to support the development of industry and commerce. These recent changes in the economic policies and general attitude in Vietnam have made it possible to address the real problem of the water supply system in Hanoi, i.e. institutional weakness. The main issues are that the quantity and quality of water do not meet the needs, pressure levels in the network are low, and reliability of supply is poor. The main causes of this include:

- poor condition of equipment (lack of maintenance skills, equipment and funds, lack of spare parts, poor knowledge of the importance of preventative maintenance)
- high water loss (poor condition of network, wastage of water, poor maintenance and rehabilitation, poor quality of existing pipelines, poor quality of construction)
- poor management and operation (low efficiency of work, lack of decision making power, a too complicated institutional set-up, lack of middle level management)
- lack of funds for operation and maintenance (economy based on subsidy system, revenues do not cover production costs, low cost efficiency, high unaccounted for water, low water tariffs).

In Figure III is presented a schematic chart which shows the main constraints affecting operation and maintenance.

According to the HWSCo the operational costs for water supply were about 12 billion Dong per year in 1989. This corresponds to reported present revenues of 11 to 12 billion Dong per annum. The revenue is partly based on agreed amounts (planned allocation transfers) and partly on tariff collection

FIGURE III


Inadequate Service Level
Quantity does not meet demand
Quality does not meet criteria
Reliability of supply is poor
Low pressure level
Inadequate production capacity
Poor condition of equipment
High water loss
Poor management operation
Lack of funds for O&M
Too low capacity of pumping and WP
Lack of detail information concerning ground water
Lack of O&M
Too old technology and equipment
Some unsuitable equipment for local conditions
Poor condition of network
Wastage of water
Improper location of well fields
Lack of knowledge of ground water resources
Lack of funds
No plan for maintenance
Unsuitable imported equipment
Improper installation
Wrong water use habits
Illegal connections
Inadequate reporting of damages in pipes
No O&M plan
Lack of equipment, tools and spares
Lack of O&M skills
Poor maintenance and rehabilitation
Poor quality of construction
Poor quality of pipes
Low water tariffs
Lack of awareness
Poor O&M manuals
Inadeuate preventive maintenance
Low number of qualified staff
No continuous training of staff
Lack of funds
Poor workmanship
Poor workmanship in construction
Too old network
Por quality of local pipes
Corrosion of pipes
Lack of tools and maintenance facilities
Lack of trainers
Lack of training material
Lack of material, spares and fittings
Lack of managers
Poor supervision of works
Lack of knowledge of importance of preventive maintenance
Inadequate material for house connection work in HWSCo
Low pressure level in network
Complicated formalities in applying for house connections
Lack of regulations for water consumers
Poor control and supervision of work
No regular maintenance programmes
Low efficiency of work
Lack of decision making power
Poor knowledge of need of spare parts for imported equipment
Lack of middle level management
Centralized decision making power
Too complicated institutional set up
Low cost efficiency
Revenues do not cover production costs
Economy based on subsidy system
Lack of HWSCo's supervision during implementation
Lack of motivation
Lack of job descriptions
Big number of unqualified staff
Poor billing system
Lack of cost control
High unaccounted for water
Low water tariffs
Lack of foreign currency fund
Lack of local products
Salary structure not motivating
High water losses
Free usage of water
Water tariffs can not be changed acc. to production cost
Payment is not based on consumption
WHO 90830

(conducted through billing centres and based mostly on consumption average estimates). The revenues by sources are: industries 54%, domestic users 45%, institutions 1%. HWSCo accounts for water production costs, including a 40% water loss, at 115 Dong m^3/d. Assuming a 200 000 m^3/d consumption this amounts to 11,3 billion Dong per annum. With e.g. electricity and salaries heavily subsidized, water loss underestimated and a non-existent stock and spare parts supply, the actual production costs must be substantially higher. Tariffs as applied in May 1990 are:

-	domestic	80	Dong/m^3	(o,o2 USD)
-	industrial	400	Dong/m^3	(0,1 USD)
-	private commerce	1000	Dong/m^3	(0,23 USD)
-	foreigners	0,45	USD/m^3	
-	consumer connections cost	300 000	Dong	(70 USD)

The HWSCo at present employs about 1600 persons. The predominant features of the organization have been centralized decision making with power being exercised at the top management level and a rigid personnel policy. The economic reforms in progress are now changing the recruitment of staff and a new contract employment system has been introduced. This new policy gives management the possibility of recruiting staff according to their qualifications and actual needs. However, job descriptions and standards of performance are not defined and recruitment policies, skill tests etc. are inadequate. There is an obvious lack of middle level management, which hampers the success of operations. At all levels management skills are inadequate.

The Transport and Urban Public Works Service (TUPWS) - the implementing agency for the project and the HWSCo have realized the problems of organization. A study on the organization and proposals for reorganization were made in February - April 1989 by the UNDP financed Hanoi Water Supply Management Project. On the basis of these recommendations pilot organizations were established

for one water plant and one water distribution branch, but it is difficult to assess the effect of these actions. In February - March, 1990 another attempt was made by the management of HWSP and the management of HWSCo to modify the organizational structure of HWSCo to enable it to function better and to allow for a more decentralized decision making process. The proposal was approved by TUPWS and will be tested between April and September, 1990.

Lack of funds and local materials for operation and maintenance are closely connected with the difficult financial situation of the HWSCo. The Project has supplied spare parts for the new and rehabilitated water plants as well as for networks as an activity of the implementation in order to assuage the spare parts difficulty.

Programme Strategy

The basic strategy for the Finnish contribution is the provision of financial and material support and technical assistance to the normal operations of the HWSCo. The Programme is flexible and the objectives, inputs and activities of the programme shall be reviewed and planned on an annual basis in collaboration with the other activities of HWSCo.

The programme is an institutional development programme accompanied by a physical component which seeks to achieve acceptable service targets by 2010. Therefore, in all activities a key issue is ensuring sustainability. The programme will rely strongly on the absorption capacity and capability of the Vietnamese implementing agency.

To help achieve sustainability in operation and maintenance the procurement of materials will be flexible and emphasis will be put on the developing of local capabilities to procure.

Technical assistance will concentrate on advising and training giving particular attention to managers, trainers, foremen and instructors. Local institutions will also be used to the greatest degree possible to help strengthen their capacities.

The Programme intends to give support to the technical facilities of HWSCo to operate and maintain the water supply system. The supporting facilities of HWSCo, such as workshops, garages, stores, water laboratory, Head Office, Distribution Branch Offices will be upgraded and rehabilitated. The facilities will be established and improved but only in parallel with an increase in the capacity and capability of the staff.

Systematic spare part procurement, storing and delivery system procedures are to be developed and HWSCo, HWSMB and other relevant organizations will be involved in all procurement procedures. The financing of spare parts for operation and maintenance will be increasingly the responsibility of HWSCo.

The progress and success of previous phases of HWSP have been limited by institutional weaknesses, insufficient co-ordination between the various parties involved in the project, centralized decision making, and inadequate management capabilities. The main emphasis in the coordination of the programme shall be given to the development of collaboration between the various agencies and to the development of proper institutional arrangements for the programme.

The major objective will be to convert the HWSCo into a self-financing and sustainable enterprise, where billing, accounting, water tariffs, regulations, personnel management, control and monitoring, planning of development and design are operating efficiently.

Utilization of existing local organizations and institutions as far as possible shall be emphasized in the implementation of the Programme. Cooperation with other water companies, and design and construction companies abroad shall be extended in the Programme and the possibilities of exchanging personnel for training shall be studied.

A Human Resource Development Plan (HRDP) shall be prepared for HWSCo, HWSMB, SewCo, DE, in accordance with the development policies of TUPWS and HPC and the annual training plans of

the Programme shall be in accordance with the HRDP. Emphasis shall be given to the development of middle level management.

Project Progress

By the end of 1989, one year before the end of Phase II of the project, the situation of the water supply in Hanoi City can be summarized as follows:

- the total raw water capacity from the new or rehabilitated wells (64 wells), which were implemented by the Project is 320 000 m^3/d.
- the capacity of water plants, which were rehabilitated or constructed by the Project is 205 000 m^3/d.
- the service level of water distribution has considerably improved in high pressure areas, which represent about one third of the total service area. Due to an increased production of water and improved reliability of distribution the availability of water is now better than ever before. This has been achieved by constructing:
  - 13 km of raw water lines
  - 35 km of transmission lines, d = 400 ... 600 mm
  - 110 km of distribution lines, d = 90 ... 300 mm
  - 7800 house connections
- the benefits of the Project are fully recognized by the population of Hanoi and the Project has high priority both for Hanoi City and for national government.
- there is a mutual understanding regarding the needs to further extend the project strategies.

The physical progress of the project in Phase II has not reached the project targets and the construction of water plants and raw water wells has been delayed. The systematic rehabilitation of transmission lines was started very late in the Project and resources for this work have been limited. However, during 1989 it was recognized by all parties that this work is very cost effective and that large

improvements in service levels could be achieved with fewer new investments. The Hanoi Water Supply Company, with agreement from the Hanoi People's Committee also instituted concrete measures against illegal connections, wastage of water and tampering with water meters.

Conclusions

Although much has already been accomplished during the five years crash programme to improve the water supply in Hanoi, there are still many problems to be solved and much remains to be done. In major areas of the City water pressure in the network is only slightly above street level, water quality in the production plants and in the network is not properly controlled, distribution interruptions in non-rehabilitated network are frequent and the service level is inadequate, operation and maintenance is still weak, water losses in the network are high, skills of staff are not developed and the financial performance of the Water Supply Company is poor.

The environmental impacts of the water supply and the urgent needs for improvement in sanitation and storm water drainage are also issues which require careful studies in order to find alternatives which are economically viable and will keep the environmental impacts at an acceptable level.

THE DEVELOPMENT OF THE DEEPWELL HANDPUMP PROGRAMME IN INDIA

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Introduction

Drilling boreholes in hard basalt formation was introduced in India in the rural water supply programme in the early 1960's by the Jalna based Church of Scotland's "War on Want" mission. While the drilling of boreholes was very successful the hand pumps fitted on these boreholes were of poor quality. They were locally manufactured cast iron copies of European and American handpumps, meant for family use rather than community use and broke down frequently.

Design improvements to handpumps were carried out by various non-government organizations in the late 1960s and early 1970s and by 1974 several thousands deepwell handpumps, mainly of three different designs i.e. Jalna, Jalwad and Sholapur were installed in many states in India. These pumps did not have standardized drawings and interchangeability of parts was impossible even for pumps of the same design.

In early 1974 UNICEF carried out a spot survey to determine the status of boreholes drilled with UNICEF provided drilling rigs. The survey revealed that at least seventy five percent of the handpumps were broken down at any given time. It was clear that unless substantial improvements were made in handpump design, quality, installation, and maintenance, no useful purpose would be served by drilling more expensive boreholes. The high failure rate of handpumps was in fact eroding the confidence of people in the deepwell handpump programme as a reliable source of safe and continuous water supply. The issues that needed urgent attention were:

- Design and development
- Standardization
- Local capacity building
- Quality control

- Installation
- Maintenance

The Government of India (GOI) and World Health Organization (WHO) organized a handpump workshop in June 1975 to discuss various issues related to deepwell handpumps. The participants in the workshop were Chief Engineers (Public Health Engineering) from various states and representatives from Mechanical Engineering Research and Development Organization (MERADO), Richardson & Cruddas (1972) Ltd., (a Government of India undertaking) UNICEF and bilateral agencies. The workshop unanimously recommended that there was an urgent need to develop a reliable and sturdy deepwell handpump.

During 1977-1989, the rural water supply programme experienced a miraculous expansion and a very high success rate. The achievements can be summarized as follows:

- Development of the India Mark II deepwell handpump and its adoption on a national scale;
- Preparation of a national standard;
- Establishment of local manufacturing capacity;
- Establishment of a quality control mechanism including vendor selection;
- Installation of 1.5 million India Mark II deepwell handpumps; and
- Development of VLOM India Mark III deepwell handpump.

This spectacular success was possible due to the adoption of certain approaches/strategies by the GOI, UNICEF and bilateral agencies. This paper discusses the various approaches/strategies followed by the GOI, non government organizations, UNICEF and bilateral agencies and how various issues were successfully resolved.

Development of an Appropriate Handpump

Prior to 1975 several handpump designs were available. These were the Mahasagar (cast iron single and double guide pumps with a number of pivot points), Jalna and Sholapur pumps. These pumps

had a high frequency of breakdown (over 75%) and were not sturdy enough for community use. The quality of manufacture was often poor and the components used were not interchangeable.

A collaborative national effort involving Tamil Nadu Water Supply and Drainage Board (TWAD), MERADO, Richardson & Cruddas and UNICEF was initiated by the Government of India in late 1975 for the development of a sturdy and reliable deepwell handpump. While the design support was provided by MERADO, (a design and development organization), the manufacturing and field monitoring were provided by R & C, a manufacturer, and TWAD Board (a state level organization responsible for providing water supply and sanitation facilities) respectively. UNICEF coordinated the development efforts and worked as a catalyst.

The criteria set out for the handpump development effort were:

1) Trouble free operation for at least one year and capable of drawing water from boreholes with Static water levels of up to 150 feet;
2) Number of people to be served - 500 persons per pump;
3) Design must be suitable for local manufacture and should not involve import of components or materials;
4) An adult must be able to operate the pump without undue effort;
5) Design to permit maintenance by people with low engineering skills; and
6) The design must be sturdy and vandal proof.

The Sholapur handpump which was then considered as the best handpump was taken as the basis for the development of a new pump. This pump design was strengthened substantially to overcome weaknesses. The design evolved as a result of intensive consultations and discussions between MERADO, UNICEF and R & C. By early 1976, ten prototype pumps were installed near Coimbatore, in Tamil Nadu State, for field testing and monitoring under the joint supervision of the TWAD Board and UNICEF. This area was selected for field testing of prototype handpumps as it had a deep water table (25-45 mts) and

usage was very high (12-16 hours). Encouraged by the field trials, a decision was taken in 1977 to field test 1000 pumps of the same design in various states. By 1978 it was very clear that a sturdy, reliable and easy to operate pump had been developed. In recognition of its Indian origin and the many Indian organizations and individuals who contributed so much to the development, this pump was called the India Mark II. The development of this pump achieved all the criteria with the exception of maintenance by people with minimal engineering skills.

Although the emergence of the India Mark II was a major breakthrough in terms of reliability and ease of operation, it relies heavily for all below ground repairs on a centralized mobile team equipped with a motorized van, special tools, heavy spares like connecting rods, riser pipes etc. and 3-4 semi-skilled workers. Due to the cumbersome maintenance procedures involved in all the below ground repairs it is not feasible to develop a village based maintenance system that is replicable.

Keeping in view the need to carry out most of the repairs at the village level the UNDP/World Bank Water and Sanitation Program, in collaboration with the GOI, TWAD Board, R & C and UNICEF implemented the Coimbatore Handpump Field Testing Project with the objective to carry out potential improvements to the India Mark II handpump. Four and half years (1983-1988) of intensive research and development work and close field monitoring resulted in the development of a VLOM (Village Level Operation and Maintenance) derivative of the India Mark II handpump known as the India Mark III handpump. This pump design facilities the extraction of the plunger assembly and foot valve assembly without having to lift the rising main. This design feature simplifies the maintenance procedure for the below ground repairs significantly.

Research and development is a continuous process and is essential to permit continual improvements in design to overcome field problems and to improve reliability and performance. At the national level a "Hand Pump Committee" has been constituted by the Department of Rural Development (DRD), GOI: with members from GOI, MERADO, State Governments, bilateral and multilateral agencies

to coordinate all research and development efforts. This ensures planned research and development efforts, dissemination of information on a national level and operationalization of field proven design improvements.

Need for Handpump Standardization

While the initial prototype pumps were being field tested in 1976-1977 various copies, imitations and substandard versions of the India Mark II design began to appear in the market. Initially, UNICEF distributed the production drawings. With the objective of standardizing on the India Mark II handpump a decision was taken by the GOI to request the Indian Standards Institution (now known as Bureau of Indian Standards) to prepare a national standard on the India Mark II handpump. Normally, a national standard does not specify dimensions and other details of components and sub-assemblies. But keeping in view the special circumstances and to ensure 100% interchangeability of components, the Bureau of Indian Standards (BIS) agreed to deviate from the usual norms. The first national standard on the India Mark II, IS: 9301 - 1979, appeared in the year 1980. This standard apart from dimensional details specifies material of construction, quality control procedures, type test, routine test, warranty clause and a procedure for quality certification by BIS. Preparation of handpump standards and review of the existing handpump standards is entrusted to a "Handpump Committee", constituted by BIS with representatives from BOI, state governments, manufacturers, bilateral and multilateral agencies and NGOs. The India Mark II standard was revised in 1982, 1984, 1986 and 1989.

The BIS provides a permanent forum at the national level for the preparation of new standards and an ongoing review of the existing standards.

The advantages of standardization were:

- There was uniformity in production and interchangeability of components improved significantly;
- Many manufacturers were ready to invest in good jigs and fixtures and tooling;

- Procurement was made simple as just a reference to the standard defined the pump in all details; and
- Inspection became more systematic.

Developing Local Production Capacity

Local production of quality pumps is one of the important elements responsible for the success of the rural water supply programme. At the request of the GOI, UNICEF undertook the role of developing and qualifying manufacturers. The procedure followed was:

1. Potential manufacturers were selected by assessing their manufacturing, organizational, and financial capacity/capability through questionnaires and works' inspection by an external inspection agency.
2. Each potential manufacturer was given a trial purchase order for 25 India Mark II pumps.
3. Technical assistance was provided to manufacturers to enable them to overcome initial teething problems.
4. The batch of pumps produced by a manufacturer was checked against the trial purchase order and also the jigs, fixture, and gauges were inspected by an external inspection agency at the manufacturers works.
5. On acceptance of the batch of pumps and approval of the manufacturing process by an external inspection agency, the name of the manufacturer was included in the UNICEF list of approved suppliers.

The GOI and various state governments issued the tender documents for the procurement of India Mark II handpumps only to UNICEF approved manufacturers. This prevented entry of incompetent manufacturers into the market.

Today there are over 45 UNICEF approved manufacturers of India Mark II handpumps located in several states. The overall annual manufacturing capacity is 300,000 pumps. The advantages derived by establishing adequate local production were:

- Pumps were available at short notice and the programme did not suffer due to non-supply of pumps in time;
- Prices were very competitive;
- Spare parts were available easily all over the country;
- Manufacturers were able to export pumps to over 30 countries in Asia, Africa and Latin America thereby earning valuable foreign exchange;
- Additional employment was created; and
- The pace of implementation of the programme was accelerated.

With a view to establishing a national mechanism all the UNICEF approved manufacturers were advised in 1983 to obtain a licence from the BIS for the manufacture of ISI certified India Mark II handpumps. All the approved manufacturers have obtained the BIS licence and manufacture ISI certified India Mark II handpumps. This mechanism will prevent entry of unscrupulous and incompetent manufacturers as all the state governments insist on the supply of ISI certified India Mark II pumps.

Quality Control of Manufacture and Installation

Vendor selection and development of local production was the first step to ensure the manufacture of a quality handpump. However, this in itself does not guarantee a purchaser the supply of handpumps confirming to the specifications. The inspection of handpumps and spares at the manufacturers' works by an independent inspection agency before despatch was therefore considered absolutely essential. For this purpose UNICEF provided, at their cost, services of inspection agencies to all the state governments for inspection of India Mark II pumps and spares ordered by the state government from the UNICEF approved manufacturers.

This was perhaps the most crucial decision that assured the supply of quality India MarkII pumps and spares during the last 13 years. This factor has contributed immensely to the success of the rural water supply programme. Every year some 150,000 - 200,000 India Mark II pumps and spare parts are inspected at the manufacturers works by UNICEF approved inspection agencies (Crown Agents and SGS (India) Pvt. Ltd.).

In order to establish a national mechanism the BIS have been requested to inspect all the India Mark II handpumps at the manufacturers works and certify the pumps before despatch. BIS is now inspecting the pumps offered by the manufacturers. In fact, at present the pumps are very often inspected by the BIS as well as a UNICEF approved inspection agency. This mechanism will ensure supply of quality India Mark II handpumps even after UNICEF withdraws the quality control support.

A supply of quality handpumps alone is not enough if the installation is not carried out properly. To improve the quality of installation the following steps were taken by UNICEF in consultation with the GOI and state governments.

1. Preparation of installation and maintenance manuals and training materials for trainers, mechanics and handpump caretakers.
2. Development of special tools which made the installation and maintenance easier.
3. Human resource development through a large number of training programmes.

These steps helped to improve the quality of installation significantly and also helped in the standardization of the installation procedure.

Maintenance and Community Management

The Mark II handpump is a mechanical device used by the community and therefore needs good maintenance support to ensure its continuous operation. Although this pump does not break down frequently, it relies heavily for all the below ground repairs on a mobile team often placed at block/district level and consisting of a motorized van with special tools, heavy spares like connecting rods and riser

pipes and 3-4 semi-skilled workers. The cumbersome maintenance procedures involved in all the below ground repairs of the India Mark II virtually rules out the possibility of the development of a village based and community managed maintenance system. The maintenance is therefore looked after by the State Government through one of the following maintenance systems namely three tier, two tier, and Trysem. All these maintenance systems depend on mobile teams located several kilometers away from the villages. It is estimated that due to delay in the reporting of breakdowns and the long response time of the mobile teams, the India Mark II on an average remains inoperative for over 30 days annually. The down time could be eliminated if most of the repairs were carried out at the village level itself.

With the emergence of the India Mark III handpump (a VLOM version of the India Mark II) it is possible to establish a village based and community managed maintenance system, as over 90% of the repairs can be carried out by a village mechanic with the help of a pump user and fewer tools.

A national workshop on "Potential Improvement to India Mark II Handpump Design" organized by the GOI on 24-25 May, 1990 at New Delhi recommended the introduction of the India Mark III handpumps on a large scale and also the establishment of a village based and community managed handpump maintenance system.

Lessons Learnt

The pragmatic approaches and strategies adopted during the last fourteen years ultimately led to the successful implementation of the world's biggest deepwell handpump programme in India involving some 1.5 million India Mark II handpumps. The main lessons learned from this experience can be summarized as follows:

1. Community handpumps should be sturdy, reliable and easy to operate.
2. The pump design should allow most of the repairs at the village level with few tools and minimal skills.

3. Standardization brings with it several advantages like reduction in cost, reduced inventory and training requirements, and interchangeability of components. It also helps in the procurement and inspection of goods.

4. Building of a local manufacturing capacity is a must and should be encouraged wherever feasible. Careful selection of potential manufacturers followed by technical assistance helps in building a local manufacturing capacity.

5. Quality control is perhaps the most important factor for the success of any programme. Expenditures on quality control is essential and economically beneficial as costly repairs at site are avoided.

6. Installation must be carried out properly. Defective installations are always a source of perennial maintenance problems.

7. The centralized maintenance system comprising a motorized van and crew and located several kilometers away from the village is expensive, complex, inefficient and difficult to sustain.

8. Human resource development (HRD) is essential for the success of a programme. Expenditure on HRD is never a waste as it creates a permanent asset.

9. For a long term sustainability it is necessary to decentralize the maintenance system. Most of the repairs must be carried out by the users themselves or a village mechanic at the village level.

UNACCOUNTED FOR WATER MANAGEMENT IN GREATER KATHMANDU

Tashi Tenzing
Kathmandu, Nepal

Introduction

Nepal is a small, landlocked Himalayan kingdom divided into three east-west bands: the northerly "Mountains", the middle "Hills" and the southerly plains called the "Terai", with a present population of about 18.5 million which is expected to grow at about 2.7% per annum over the next decade or so. Rainfall varies but is typically about 1500 mm annually with 80% falling in June to September (the monsoon season) which is out of phase with the seasonal water demand which generally reaches a maximum in the dry months of April and May.

Lying in the middle "Hills" of Nepal is the Kathmandu Valley with an approximate circular diameter of 30 km and surrounded by hills rising to 2000 m in altitude and with a floor elevation of 1300 m above mean sea level. The Kathmandu Valley towns include Bhaktapur (which has a separate water source and distribution system), Kathmandu and Lalitpur.

Kathmandu-Lalitpur (also known as Greater Kathmandu) has a present (1990) population of 460,000 which is projected to increase to about 879,000 by the year 2005. Greater Kathmandu presently faces a severe and steadily deteriorating water crisis with leakage and wastage estimated at about 60 percent.

Water Supply - Leakage and Wastage Control

The history of piped water systems to Greater Kathmandu dates back to 1895 A.D. when the Bir Dhara system was constructed. Subsequently there have been various additions to, and extensions of the system, particularly, under three World Bank (IDA) assisted projects.

Evolving from a UNDP assisted "Master Plan for Water Supply and Sewerage for Greater Kathmandu and Bhaktapur" prepared by consultants in 1973, the "First Project" commenced in 1974 to

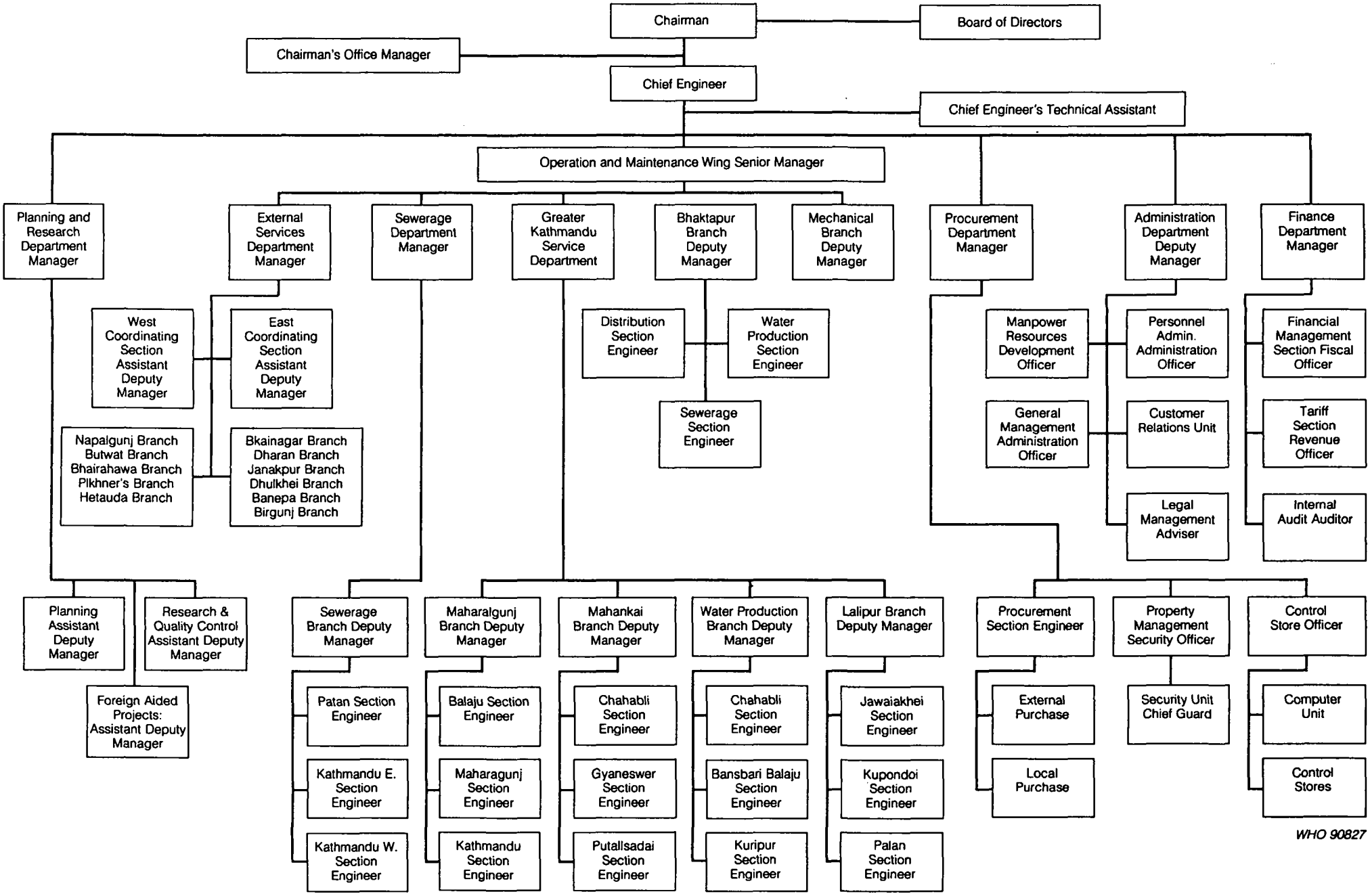
include water supply and sewerage improvements to Kathmandu-Lalitpur, and water supply to Bhaktapur and Pokhara. A "Second Project" started in 1979 to strengthen and extend the distribution components of the water supply and sewerage systems initiated under the First Project. Water supply improvements to Birgunj and Biratnagar and an update of the 1973 Master Plan were also included under this project. Subsequently, a "Third Project" was commenced in 1980 to include further water supply and sewerage improvements in Kathmandu and Lalitpur and water supply to Bhaktapur, Pokhara, Birgunj, Biratnagar, as well as Nepalgunj, Bhairahawa, Butwal, Hetauda, Janakpur and Dharan. This project was officially closed in June 1988.

Additionally, an important objective of all three IDA projects was to assist the development of the Water Supply and Sewerage Board (WSSB), (which was created in 1974 to execute the First Project), into a self-sufficient public utility able to improve and extend water supply and sewerage services to other urban areas in the country.

However, like other Boards in Nepal, WSSB was a temporary creation to implement projects. Hence in July 1984 the WSSB became the Water Supply and Sewerage Corporation (WSSC), a semi-autonomous government corporation with a broader responsibility and greater responsibility in the management of water supply and sewerage.

The legal powers of WSSC were also found inadequate to enable the water/sewerage system to be managed efficiently, as a result, under a new Act, WSSC became the (autonomous) Nepal Water Supply Corporation (NWSC) in February 1990. Under this Act, NWSC has responsibility for urban water supply and sanitation in all 33 town councils in Nepal. Presently, NWSC has taken over operations of only those 12 towns administered by its predecessor. The NWSC operates under a Board of Directors and falls under the Ministry of Housing and Physical Planning. NWSC enjoys greater autonomy with powers to set its own tariffs and take action against defaulters. In practice, however, the government of Nepal exercises control on NWSC's activities. The organization chart for NWSC is shown in Figure I.

Figure I


Chairman
Board of Directors
Chairman's Office Manager
Chief Engineer
Chief Engineer's Technical Assistant
Operation and Maintenance Wing Senior Manager
Planning and Research Department Manager
External Services Department Manager
Sewerage Department Manager
Greater Kathmandu Service Department
Bhaktapur Branch Deputy Manager
Mechanical Branch Deputy Manager
Procurement Department Manager
Administration Department Deputy Manager
Finance Department Manager
West Coordinating Section Assistant Deputy Manager
East Coordinating Section Assistant Deputy Manager
Napalgunj Branch
Butwat Branch
Bhairahawa Branch
Pikhner's Branch
Hetauda Branch
Bkainagar Branch
Dharan Branch
Janakpur Branch
Dhulkhei Branch
Banepa Branch
Birgunj Branch
Distribution Section Engineer
Water Production Section Engineer
Sewerage Section Engineer
Manpower Resources Development Officer
General Management Administration Officer
Personnel Admin. Administration Officer
Customer Relations Unit
Legal Management Adviser
Financial Management Section Fiscal Officer
Tariff Section Revenue Officer
Internal Audit Auditor
Planning Assistant Deputy Manager
Research & Quality Control Assistant Deputy Manager
Foreign Aided Projects: Assistant Deputy Manager
Sewerage Branch Deputy Manager
Maharalgunj Branch Deputy Manager
Mahankai Branch Deputy Manager
Water Production Branch Deputy Manager
Lalipur Branch Deputy Manager
Patan Section Engineer
Kathmandu E. Section Engineer
Kathmandu W. Section Engineer
Balaju Section Engineer
Maharagunj Section Engineer
Kathmandu Section Engineer
Chahabli Section Engineer
Gyaneswer Section Engineer
Putallsadai Section Engineer
Chahabli Section Engineer
Bansbari Balaju Section Engineer
Kuripur Section Engineer
Jawaiakhei Section Engineer
Kupondoi Section Engineer
Palan Section Engineer
Procurement Section Engineer
External Purchase
Local Purchase
Property Management Security Officer
Security Unit Chief Guard
Control Store Officer
Computer Unit
Control Stores
WHO 90827

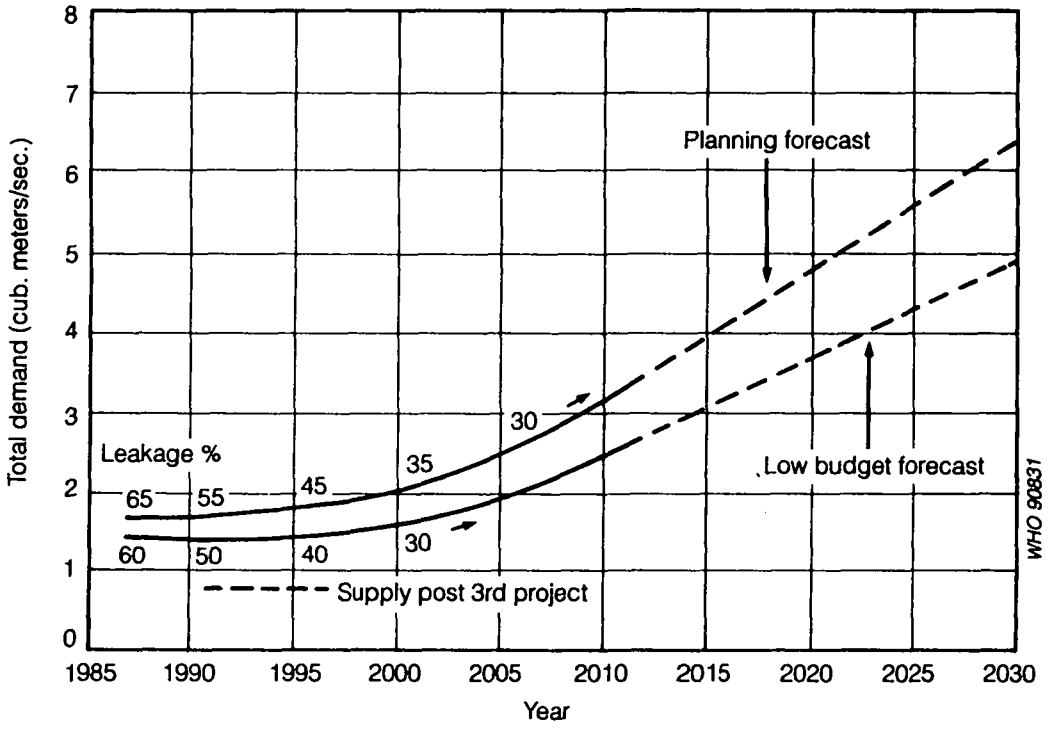
Leak detection and repair was given very little attention prior to 1974 when the estimated leakage in the system was reported as 75%. Between 1974 to 1977 under an Overseas Development Agency - UK assistance the (then) WSSB staff were trained to actively search for leaks quickly and efficiently. Two inspectors of the WSSB were trained in the United Kingdom; one in leak detection and the other in metering. At the end of the project WSSB was left with a considerable amount of equipment such as stethoscopes, pipe and leak detectors, valve locators, two mobile wastemeters and the like. However, WSSB was not able to sustain any programme of leakage control and the equipment deteriorated out of service. In 1987 a German government (GTZ) assisted leak detection and repair study was carried out in two pilot areas in Kathmandu: Baneshwor and Maharajgunj covering an area of 260 hectares (about 4% of the supply area).

In spite of past efforts the water supply system of Greater Kathmandu has deficiencies in water quality and service levels. High levels of iron, manganese and ammonia in groundwater and pollution through infiltration of contaminants due to low pressure, intermittent supply, rapid urban growth, depletion of sources of water in the valley and excessive amounts of unaccounted for water are of grave concern.

To address the deficiencies in a comprehensive manner, His Majesty's Government of Nepal (HMGN) embarked on a Fifteen Year Development Program (FYDP) for NWSC. In Greater Kathmandu the FYDP proposes to extend the present 6-hour per day water supply to 24-hours by 2005. Figure II shows the future water demand for Greater Kathmandu. It is expected that the shortfall of supply would be achieved through rehabilitation of, and extensions to the existing water supply facilities, and development of new outside the valley, water sources. Improved operation and maintenance becomes imperative to manage the additional resources effectively. Improved and expanded wastewater facilities would be provided concurrently.

FIGURE II

Water demand forecasts for Kathmandu and Latipur



HMGN/NWSC recently negotiated with IDA a credit for US$ 60 million for a Water Supply and Sanitation Rehabilitation Project (WSSRP) to cover part of the first phase of the FYDP. The WSSRP focuses on activities to achieve managerial, financial and operational improvements and rehabilitation, extensions and improvements to the water/sewerage systems.

The water and sanitation sector efforts have been governed by HMGN's urban water supply and sanitation sector objectives to provide:

1. a 24-hour supply of affordable and safe drinking water to all the urban population by 2005;
2. affordable sewerage/sanitation facilities to the urban people by the year 2005; and
3. strengthening of NWSC's operational capabilities and financial viability.

Water Supply

At present, about half of the water supply to Kathmandu-Lalitpur comes from surface sources and the other half from tubewells (groundwater) from within the Kathmandu Valley. The supply is stored in four reservoirs servicing the two cities and distributed through a network of 50 mm to 800 mm diameter pipelines extending to about 300 km to cover an area of about 50 square kilometers and to serve a 1989 population of about 430,000 which is expected to rise to some 870,000 by the year 2005 and around 1.3 to 1.5 million by 2011. Water is currently being released from the reservoirs for only 3 hours each morning and evening, which provides many consumers, particularly those living in higher areas with water for only about half an hour during each period. There are approximately 55,000 connections in Kathmandu-Lalitpur of which 85% are metered; but 45% of the meters in Kathmandu and 30% in Lalitpur are believed to be defective and not functioning correctly. The original distribution system, about 100 years old, has been extended over the years and consists mainly of cast iron (CI) and ductile iron (DI) pipes with diameters of 80 mm to 800 mm and galvanized iron (GI) pipes for diameters less than 80 mm. The system has serious deficiencies and a very high proportion of unaccounted for or "lost" water which coupled with the inadequate supply from the existing sources creates a wide variation in pressures and levels of service. The intermittent supply causes water pressure in the mains to fall during non-supply hours and even to become negative allowing infiltration of contaminated groundwater into the mains through leaks in pipes or joints thereby posing a potentially serious health hazard.

Groundwater is being mined due to non-availability of surface sources within the Valley. The surface waters being tapped at present are treated in four treatment plants while most of the groundwater, containing iron levels up to 6 mg/l and ammonia, receives only chlorination. When borehole water is mixed with treated surface water, iron flocculation occurs causing serious operational problems like choking of meters, reducing pipe sizes, odour and staining, consumer resistance to paying and meter tampering. Deficiencies in the distribution system result in some areas receiving less than the twice daily

three-hour supply while a few locations enjoy a continuous 24 hour supply. The current demand is 54 mld and the supply 65 mld of which about 26 mld (40%) is unaccounted for water through losses in the system, wastage and theft. The "lost" water is estimated to increase to over 60% in the event that water is supplied 24 hours per day. The inadequate supply is augmented for public standposts users through tankers supplying water to small tanks located in areas of low pressure. The higher income residents have installed ground level and over head tanks to assure themselves of a de facto 24 hour-supply. Current procedures and practices for pipe laying, ferrule specification, testing and service connections are thought to contribute significantly to water losses.

NWSC's operation and maintenance (O & M) performance has been far from satisfactory. The organization lacks sufficient personnel adequately experienced in managing a water/sanitation utility. On-the-job training or formal training for middle and junior level staff to improve efficiency are lacking. NWSC has not yet developed standard practices for operations e.g. preventive maintenance, pipeline laying and maintenance, treatment and contract supervision. Despite past assistance, NWSC continues to repair only passive leaks, and much of the leak detection equipment is out of service and/or under utilised.

Major Constraints to Operation and Maintenance

The Nepal Water Supply Corporation currently suffers from serious financial and operational weaknesses, and is in need of widespread improvements in all departments. The organization is expected to finance its operating expenses from tariff revenues. NWSC's annual revenues, currently about NRs. 34 million (US$ 1.36 m) falls far short of the present operational budget of about NRs. 66 million (US$ 2.64 m). This deficit has forced NWSC to make short term savings at the expense of quantity and quality of water and needed maintenance. The result has been a steady deterioration of service levels and growing customer dissatisfaction reflected in illegal connections, tampering with meters to avoid payment, blockage of meters due to poor water quality, other abuse of facilities by users, and large arrears in revenue collection, adversely affecting NWSC's cash flow.

Apart from financial resources, NWSC is weak in management, construction supervision, and operation and maintenance. Poor personnel management has resulted in overstaffing and low morale among the staff for whom proper training to develop their skills is not provided. Supervision by poorly motivated staff and poor procurement practices (based on lowest bid) and selection of materials for use without proper assessment have led to an inferior quality of the water/sewerage systems. This has been aggravated by increasing public demands on the system which has led to the laying "Spaghetti" service connections buried at shallow depths with poorly jointed galvanised pipes. Substandard internal plumbing has also added to wastage of water as the low tariff structure, shown in Table I, does not provide an incentive to conserve water.

The situation continues to deteriorate as the groundwater sources in the valley are being mined and the intermittent supply causes health hazards. There is an urgent need for improved utility management; to introduce sound groundwater management; address the reduction of unaccounted for water; augment the supplies; and improve water quality.

TABLE I

NWSC PRESENT AND PROPOSED TARIFFS

Tariffs for Metered Connections

Size of Connection (mm)	Minimum Quantity ('000 liters/month)	Minimum Charge (NRs.)		Rates for Additional Units (000 liters)(NRs.)	
		Present	Proposed	Present	Proposed
15	10 1/	7	7	1.20	2.50
20	27	28	88	1.20	3.25
25	50	56	200	1.20	4.00
40	140	168	665	1.20	4.75
50	235	280	1,293	1.20	5.50
75	700	840	4,200	1.20	6.00
100	1,400	1,680	8,400	1.20	6.00

1/ The minimum quantity in the proposed tariff is 5,000 liters for 15 mm connections only.

Tariffs for Unmetered Connections

Size of Connection (mm)	Tariff (NRs./month)	
	Present	Proposed
15	13	30
20	45	195
25	90	480
40	270	1,425
50	450	2,640
75	1,350	5,760
100	2,800	11,520

Operation and Maintenance Strategy

It is extremely important for Greater Kathmandu that proper management for water losses be instituted in NWSC. The past efforts in this respect have not been sustained. Leak detection and repair

has always received less attention with greater emphasis being given to construction activities. This has resulted, as discussed earlier, in NWSC maintaining a passive leakage control policy relying on leaks spotted by inspectors or reported by beneficiaries. A gang consisting of 3 to 4 persons (a plumber and labourers) is sent to repair the reported leaks and, presently repairs about one to two leaks per day. This is due mainly to lack of transportation. The Leak Detection and Repair Study provided under the German government assistance programme clearly showed that the skills learnt and practised during the programme did not continue to the same degree after the end of the project. Lack of incentive payments to leak repair gangs appear also to contribute to a marked deterioration in repair productivity.

The German assisted leak detection and repair study in two pilot areas in Baneshwor and Maharajgunj (divided into three sub-areas: Chandaul, Dhumbarahi and Ring Road - 1) show that with the twice daily intermittent supply about 20% of the supply is wasted, while about 40% is attributed to leakage. Because of intermittent supply and low pressure in the mains (0-10 m) an electronic leak detection project was not successful in the pilot areas. The study found (i) a low state of personnel training; (ii) poor organization and motivation; (iii) problems of transportation; (iv) difficulties procuring spare parts; and (v) lack of essential tools.

The Fifteen Year Development Programme stresses that the water supply to Greater Kathmandu can be improved only by adopting a programme approach that addresses both the physical rehabilitation and extension of existing water supply networks together with some sewerage and sanitation as well as augmentation of the systems and the software part that emphasizes management improvements and cost recovery. The Water Supply and Sanitation Rehabilitation Project (WSSRP) for greater Kathmandu includes management support to assist NWSC in improving management; operation and maintenance; a consumer education programme; training for NWSC staff; assistance in future project preparation; detailed design and construction supervision; water supply rehabilitation, treatment; design of new sources for future water supplies in the Kathmandu Valley; sewer system rehabilitation and sanitation and the

provision of central facilities such as vehicles, plant, equipment; and effective unaccounted for water management.

However, conventional leak detection and repair are not feasible for intermittent supplies and it will be some time before Greater Kathmandu can have a 24-hour supply. Therefore, NWSC has prepared a proposal to conduct a leak detection and control programme by pressurizing sub-zones in Greater Kathmandu. This strategy has already been carried out successfully in Madras, India where Metrowater has conducted a leak detection/repair survey. The results of this work have revealed significant leakages averaging 180 litres/connection/hour at 5 m pressure mainly at unsatisfactory ferrule connections and service pipes which account for 90% of the identified leaks. Repairs and retesting of selected areas indicated significant leakage reduction, up to 50% to 80% in some cases. This was achieved at a repair cost averaging US$ 42 per leak repair point resulting in a significant cost benefit for Metrowater.

In order to prevent excessive wastage of water, NWSC plans to establish a consumer education and community participation department as well as to develop programmes to install ballcocks on ground and roof storage tanks.

Results Achieved

It is obvious that no significant achievements in the way of operation and maintenance and management of unaccounted for water have been seen so far in the Greater Kathmandu water systems. However, the realization by the government and the Nepal Water Supply Corporation of the problems faced in the urban water sector and the endorsement of a comprehensive programme under the FYDP beginning with the IDA financed WSSRP is a positive step which it is hoped will bring about changes in NWSC to make it a competent water utility and that the leak detection effort will result in a sustained methodology appropriate for leak detection and repair for intermittent supplies.

OPERATION AND MAINTENANCE OF WATER SUPPLY AND SANITATION SYSTEMS IN BRAZIL

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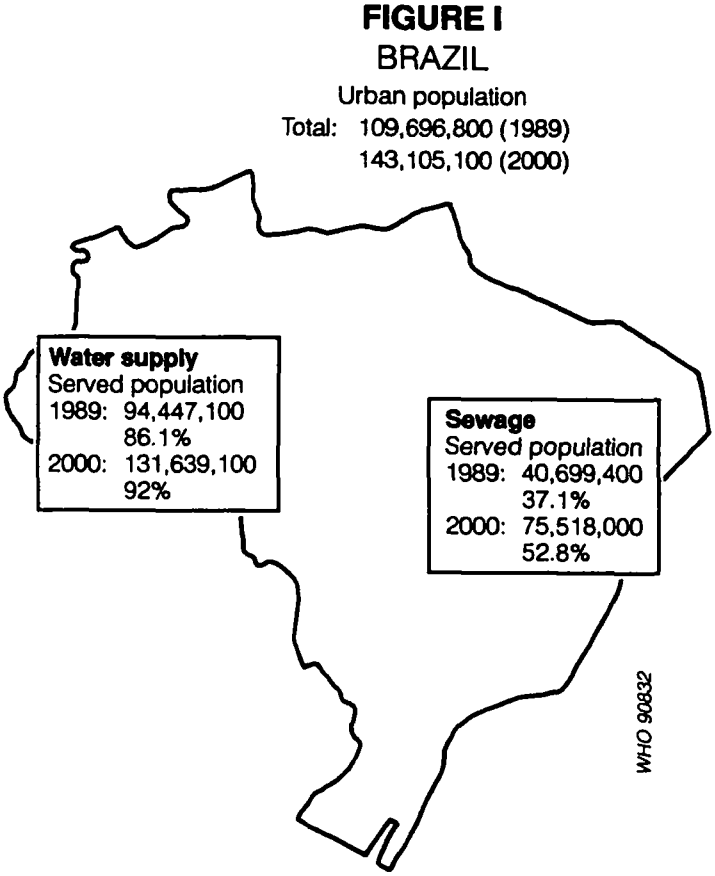
Sao Paulo, Brazil

Introduction

Sanitation services in Brazil are the responsiblity of three different levels of government; Federal, State and Municipal. After the promulgation of the new Brazilian Constitution in October 1988 and when the new President took office in March 1990 these services were reorganized. There is a National Sanitation Secretary, subordinated to the Ministry of Social Action which is reponsible for the definition of policies, guidelines and goals and the direction of the funds for this area. There is also a Financial Agency in the Ministry of Economy which is responsible for applications for funds.

FIGURE I



The design, construction, operation and maintenance of the water supply and sanitation services is the mandate of the States and the individual Municipalities. There is a Company in every state which is responsible for the water supply and sanitation service for the various municipalities. In addition to these, in each state several municipalities operate and maintain their own services. In total there are twenty-six State Companies in Brazil which serve approximately 4500 towns and there are 2500 Municipal Services. The States Companies cover about 80% of the served population and the remaining 20% is served by the Municipal Services.

Service levels for water supply and sewage in Brazil for 1989 and projected levels of service for the year 2000 are given in Figure I. Levels of coverage vary throughout the country and the percentages of the population provided with water and sanitation services are presented in Table I.

The necessary investment to achieve the projected service levels increase in water by the year 2000 is 8.3 billion US dollars while 2.6 billion US dollars will be required for sewage.

Table I

Region	Water (1989)	Sewage (1989)
North	80.7%	6.7%
North East	72.3%	8.1%
Middle West	75.2%	23.9%
South East	93.2%	60.0%
South	88.8%	16.2%

During the last twenty years only State Companies have received funds from the Federal Government. The Municipal Services relied on Municipal funds which were generally insufficient. This situation resulted in a marked difference in the quality of the service offered to the population. The State Companies had more technical and managerial resources than the Municipal Services and so provided higher levels of service. The new Federal Government is modifying this policy and intends in future to

distribute funds directly to the municipalities to help improve their service levels. Currently privatization of facilities is being tested in Brazil. One of the sewage treatment plants in São Paulo state is now totally operated and maintained by a private company and other states are considering similar experiments.

This privitization of water and sanitation systems has a lot to recommend it and may well be the most effective means of achieving more efficient operation and maintenance for water and sanitation facilities.

The Operation and Maintenance Programme

Traditionally, investments in water supply and sanitation in Brazil were made for system extensions and new constructions. Large systems were constructed, mainly in water supply, to satisfy the great increase in urban population. When the facilities were completed it was necessary to develop an operation and maintenance structures, to sustain the services. The operation and maintenance programmes developed by the water and sanitation companies have the following overall goals.

- The improvement of established systems in order to postpone new construction.
- The reduction of operational expenses through the elimination of unnecessary wastages.
- The application of a uniform planning system to all the areas of the Companies involved in operation and maintenance.
- Reduction in unaccounted for water.
- To set a high level of preventative maintenance in order to increase the reliability and the regularity of the services.
- To establish operational standards that include designs incorporating local criteria.
- To develop new, more efficient and cost effective technologies.
- To improve operational security to reduce the number of accidents.

A new technical and management structure was created to achieve the improvements in operations and maintenance. This structure is directed by a general manager, assisted by a consultative council which comprises all the managers of the areas involved in operation and maintenance.

In order to institutionalize operation and maintenance programmes in the Companies as a permanent activity a number of steps were taken:

1. The programme was given priority in the Companies as one of the main activities.
2. A managerial structure was created for the programme.
3. An awareness campaign was established to demonstrate the benefits to the Company, Employees and Customers of the new O/M programme.
4. A training programme was initiated for the employees involved.

Unaccounted for Water and Loss Control

Unaccounted for water is a major problem in operation and maintenance and an objective of the Brazil operation and maintenance programme is to reduce unaccounted for water. The experience of São Paulo state, the largest and most populous of the states is an example of how this problem is being approached in Brazil. SABESP (The São Paulo State Water Supply and Sanitation Company) is responsible for operation and maintenance both in the metropolitan area of São Paulo and in other areas of the state.

In the metropolitan area of São Paulo current losses are expected to be around 29% compared to 36% in 1976, which was the year in which the loss control programme was initiated. The losses to the distributing system are as follows:

- Total produced water 100,0%
- Effectively used 80,0%
- Accounted for 71,0%
- Unaccounted for 9,0%

1)	Not registered by meter	6,0%
2)	Illegal connection/others	3,0%
- Water not effectively used		20,0%
1)	Leakages/breakages from pipelines	6,0%
2)	House connection leakage	12,0%
3)	Overflow	2,0%

SABESP in the Metropolitan region of São Paulo covers an area of 8,500 km^2, treats up to 50 m^3/sec of water, operates 1000 kilometers of supply lines, and services 2.2 million metered connections. The urban population served is 15 million dispersed in 35 towns.

The water and sewage network is complex and in order to reduce losses the operations and maintenance programme is adopting a new strategy. The first step was a study which collected accurate data on the areas covered, system parameters such as pipe age and types of pipes, existing pressure ranges, leakages and geotechnical information.

Based on this information the following activities were undertaken:

1. Detection of non visible leaks in critical areas with high pressures, (more than 60 MCA) water distribution network age (more than 30 years) and zones with above average leakages and breakages.
2. Cleaning and cement mortar lining of pipelines older than 25 years which are non-coated and have low roughness coefficients.
3. Replacing galvanized iron house connections older than 10 years with high density polyethylenium
4. The replacement of pipelines in certain critical areas where age or pipe diameters made it prohibitive to rehabilitate by cleaning and lining.

To accurately determine losses, breakages and leakages in the São Paulo metropolitan area the company is employing a range of techniques and equipment.

1. Macrometers that were operating inadequately were replaced resulting in increases in measured water production up to 500 litre per second (1% of the measured volume in the metropolitan region of São Paulo).
2. Eighteen large meters were repaired and reactivated resulting in a gain of US 46,470 for the company.

3. The operational control system was made more efficient through the acquisition and reutilization of primary elements and pressure transmitters.

4. In order to improve pitometry for determining flows and pressures new prototype units were manufactured that provide for a greater accuracy and security for field workers. Metering of users' consumption was also improved.

5. The metering system was improved and a better reading accuracy was enforced.

   - Meters with capacities of 5, 7 and 20 m^3/h were eliminated thus reducing the costs of maintaining these items in stock;
   - It is proposed to manufacture, and test 1.5 m^3/h capacity meters in order to minimize manufacturing costs and guarantee the functioning of the instruments within their optimum range of nominal capacity;

- New selective criteria were established for meters maintenance. Currently the following criteria are used for replacement times.

  - up to 10 m^3/month ... no replacement
  - 10 m^3 to 20 m^3/month ... replacement every 13 years
  - more than 20 m^3/month ... replacement every 10 years

The adoption of these new criteria have resulted in a gain of approximately US$4.335.000 a year, as compared to the former policy where meters were automatically replaced every five years.

In order to ensure material standardization and standardization on service connections, the programme:

- has purchased and established follow-up procedures for the replacement of 15,000 segments of galvanized iron in meter shelters with PVC and PAD ones.
- planned for the replacement of 36,000 galvanized iron house connections by PAD connections over a 10 year period.

In order to decrease water losses the company:

- has initiated a campaign asking the population to phone in reports of leakages. This has resulted in an increase of 20% in reports over the last 4 years.
- has repaired visible leakage faster through better usage of material and personnel. In 1986 87,280 leakages occurred and the average time per repair was 33.5 hours. An operation called "LEAKAGE HUNTERS" has been established in the company. This group has 24 well equipped vehicles which are used to repair leaks in connections and pipelines of up

to 100 mm diameter. The use of these vehicles has resulted in a reduction in the repair time to less than 24 hours in 95% of the registered cases.

- has searched for non visible leakages. There are 680 leaks reported per month and the programme has repaired 490 leakages a month on average. In order to detect and locate leaks acoustic and correlational detector and electronic and mechanic geophones are employed. French equipment DFO from METRAVIB and German DK 2000 from SEBA Dynatronic are the two most commonly used equipment units.
- The hydraulic performance of systems has been improved through a rehabilitation programme of cleaning and lining which allows for a better hydraulic capacity. The improvements measured by the coefficient "C" of the Hazen-Willians formula, have been, on average in the range of 64 to 129, thus reaching values similar to those in new pipelines. Sixty kilometers of pipelines (diameters 200 to 1000 mm) were rehabilitated under the auspices of the programme by the end of 1989.

A number of general non-technical measures have also been undertaken to improve operational efficiency and cut down on losses to the system.

- The works at the Centro de Controle CCO (Operational Control Center) were improved. This Center has operated with the same lay-out, two COBRA 700 computers for 9 years. These computers have been replaced by two COBRA 1200 units with the inclusion of new video terminals, printers, software thus enabling the increase of 48 more telemetric points, predictable month consumption models etc.
- A study is underway on the feasibility of updating the telephone answering service system through automatization of its operation. By doing so we expect to deal faster with leakage information thus reducing the repair time and providing better services to the population and improving the company's image with the public.
- A programme to alert consumers to avoid water losses has been initiated.
- The company has been alerted to the fact that it is experiencing losses in sales of up to 3% due to special social tariffs which are being applied in squatter areas.

The programme to reduce losses been operational for 13 years. It has been quite successful and has resulted in a 7 percent decrease unaccounted for water. I has been reduced from 36% in 1976 to 29% in 1990 which is equivalent to a saving of 3.5 m^3/sec of produced water.

OPERATION AND MAINTENANCE OF URBAN AND PERI-URBAN WATER SUPPLY SYSTEMS

Jan G. Janssens
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Introduction

Strategically planned, systematic, and well organised operations and maintenance (O & M) afforded a high management priority, is an integral and essential factor in the successful operation of any water supply system. Failure to recognise its importance and consequent lack of attention to this function is a principal cause for the defective performance of many water undertakings throughout the world.

This paper reviews the major issues affecting operations and maintenance performance and presents the results of a survey of operation and maintenance practices in 9 Asian cities.

The paper concentrates on the situation in urban and peri-urban areas, largely because it is based upon information derived as the result of a questionnaire circulated to city water undertakings within the Asian region. The approach in urban areas, although similar in principle to rural, is governed by very different technical and physical considerations, and to try to deal with the two environments in tandem would have required continuous qualification in comments and conclusions. The paper recognises, however, the complementary and influential relationships between the effective management example of urban areas and improvement in the larger but less populated rural districts.

The paper emphasises the essential relationship between all disciplines of management; none can be effective in isolation. Therefore O & M is dependent upon Executive will in providing financial resources; management commitment to training skilled staff and applying its resources consistently to planned objectives; and effectiveness in obtaining reliable income from its customers to finance, wholly or partly, the carrying out of that management policy.

Well managed undertakings are dependent upon adequate resources and appropriately skilled staff at all levels. There is evidence that although management is of a high calibre at senior and middle

management levels, in many cases standards are far from consistently maintained throughout the lower strata where the 'hands on' work needs to be carried out.

Operation and Maintenance Practice and Development

Operation and maintenance are essential in safeguarding adequate drinking water supply. Most people recognise that in developing countries the operation and maintenance practice does not warrant priority. Fortunately, there is growing recognition that operation and maintenance is essential, both by planners and the financiers, as well as by the designers and operators of the water supply systems. Over the past decades many projects, achieved through very major financial and technical efforts, have performed insufficiently or broken down after only a short period of time.

Factors which may cause inadequate operation and maintenance include:

- insufficient awareness of the necessity of efficient operation and maintenance;
- inadequate management;
- lack of definition of responsibility for certain operation and maintenance tasks;
- inadequately educated and trained personnel;
- lack of operational information;
- insufficient maintenance equipment;
- shortage of spare parts;
- lack of funds;
- use of inappropriate technology which is difficult to maintain.

An additional cause of inadequate operation and maintenance can be that a system design has been inappropriately geared to the local circumstances and conditions. In many cases this results from insufficient consultation between planners and designers on the one hand, and the operators on the other.

Operation and maintenance practice must be systematically developed one step at a time. The policy and strategy of all bodies involved in protecting drinking water supply projects will need to

concentrate increasingly on the importance of that aspect, as much as on the system itself. Managers will have to recognise the adverse effects of inefficient operation and maintenance. This may lead, directly or indirectly, to:

- serious faults in the water supply system;
- threats to public health;
- drop in income from water sales;
- high costs of renovation of the system or the need for additional investment;
- an adverse effect on public opinion;
- demotivation of the personnel involved.

The policy of authorities responsible for drinking water supply should aim at creating circumstances which are conducive to the development of efficient operation and maintenance.

General Approaches to Operation and Maintenance

It is customary for 'Operation' and 'Maintenance' to be discussed in combination, demonstrating that maintenance is an integral part of successful operation. The reason why efficient operation and maintenance are vital is simple: only in this way will supply systems function satisfactorily and continue to do so in the future; and equally, satisfy quality and quantity standards, meet guidelines including those of reliability and economic return, and comply with the overall policy laid down by a particular water supply company.

The definition of appropriate requirements is in itself a difficult question. In many industrialised countries the obligations of water supply companies are statutory and therefore outside their control. Each company is required to ensure that consumers receive an uninterrupted supply of drinking water 24 hours a day, in sufficient volume and under a stated pressure. Equally, water quality must be maintained to nationally agreed-standards. This is reasonable and straightforward by definition, but far more difficult

to satisfy in everyday practice. A number of important issues which affect the operation and maintenance of water supply facilities can be identified.

1. **Reliability**

In order to comply with requirements, a water supply system must be reliable from source to consumer. Only then can management satisfactorily meet its obligations, and this is one of its most important responsibilities.

But what is the correct assessment of 'reliable'? As in most management decisions, technical standards are important but are invariably influenced by financial considerations. Naturally also, the policy of the water supply company involved substantially determines the level of reliability required. The more consumers depend on the reliability of parts of a system, the higher the degree of reliability needed for those parts. The acceptable degree of reliability decreases from source to tap.

2. **Costs**

It is technically impossible to achieve 100% reliability even if finance were no object; however, inevitably finance is always a factor to take into account. Management has the responsibility to operate a company with financial prudence, no matter whether it be public or private. Water tariffs must be accepted as reasonable and fair by consumers, but set at a level to enable management to operate effectively and plan for long-term investment.

The desired degree of reliability largely influences how operation and maintenance are executed. The higher the standard, the more money must be spent on design as well as operation and maintenance. Simply, total investment costs and the costs of operation must be optimised. Economy in maintenance generally results in higher costs ultimately. Equally, sound design can substantially reduce maintenance costs.

3. **Design**

When planning a water supply system, the method of supply is determined by the available source and on the basis of a number of fundamental requirements - capacities, quality, catchment area, population to be served.

On the other hand, operational performance and concept allow scope for a broad range of alternatives. The selection of system components must be made with great care, particularly in relation to maintenance requirements. Equally the selection of pipeline materials is as important as the choice of pumps or the decision on the overall operational system itself.

The essential basis for long term and smoothly operating supply systems is good initial design.

4. Preventive Maintenance

It is self evident that maintenance involves much more than merely making emergency repairs in the event of faults or malfunctions. Systems and installations will only perform reliably and consistently when preventive maintenance is carried out regularly.

Preventive maintenance involves carrying out a programme of work according to a predetermined schedule for each section of the water supply system, and on a regular calendar basis. The design of an effective maintenance schedule requires experience and practical expertise. This means that the practical operators of the system should have a considered input into, and influence on, the design of a schedule and on its re-assessment; it should not be static, but must be varied with experience, being tested regularly against practical circumstances. For this reason it is impractical to provide standard set rules in perpetuity.

Naturally the directions for maintenance provided by the suppliers of systems components, for instance, mechanical and electrical equipment, will be incorporated in any maintenance schedule. However, even these need to be tested in practice and consequently the schedule must be dynamic and flexible.

The important criteria for evaluation of any schedule is simply, the level and number of faults in production and distribution. This requires accurate recording and analysis of malfunctions; no more so

than in the case of technically complex and sensitive purification systems with a multiplicity of components and expensive metering devices which are prone to operational defect.

Preventive maintenance to achieve optimum operational efficiency of an installation is a precondition for success.

5. **Rehabilitation**

Maintenance and repair of systems can prolong their operational life but only for a finite period. Ultimately the cost of maintenance will become uneconomic because of frequency of faults, and replacement will be necessary. Thus cost evaluation is important, but the most efficient and planned maintenance and replacement policies which keep systems in working order over extended periods, should not preclude, if appropriate, the replacement of a system that has become dilapidated, although still functional.

This radical assessment needs to be made periodically, for in many cases the practical and technically functional span of a system exceeds its economic relevance. This happens particularly where maintenance has been carried out diligently and correctly. Systems may become obsolete earlier than expected because of quality requirements or reliability needs, and management must always be sensitive to the balance between technical and economic considerations.

6. **Quality**

Water quality monitoring is a comprehensive and vital element in operations. Surface water supplied by means of extensive distribution networks demands that numerous samples are taken and that a wide range of parameters are monitored. Chemical, bacteriological and biological testing must be widely executed. Water quality can easily deteriorate in a distribution system and systematic testing is essential if the most important aim of bacteriological reliability of water supply is to be safeguarded.

Water quality investigation needs fully equipped laboratory resources and qualified personnel. Normally water supply companies maintain their own laboratory services, although some are shared with

other utilities. It is important that water quality monitoring is organised on an independent managerial basis so that its objectivity is absolute in assessing the needs and requirements for the protection of consumers.

7. **Spare Parts**

Without a planned and comprehensive supply of the required spare parts and repair sets, effective, timely and technically correct maintenance is not possible. The quantity of spare parts available for each of the countless technical components which are part of the water supply system must be assessed so that they are always available at the time they are needed and that stocks are kept at a sensibly larger level than immediately required.

The stock should be determined by the frequency of the occurring malfunctions of a component and the delivery period of spare parts. Excessive stock occupies space and is expensive. It goes without saying that not only quantities must be assessed correctly, but that quality also demands close attention. Spare parts and repair sets can be stocked either centrally or strategically, or in a combination of the two. This must depend on the size and the organization of the water supply company. With large companies, the purchase of materials, and stock management, are often the responsibility of a separate section within the organization, to achieve proper economics of scale in purchasing.

An important aspect of materials supply is standardization. The number of spare parts can be reduced substantially when less dissimilar components of the water supply system are chosen. Standardization is most effective when applied to components of the distribution network, which are large in quantity: pipes, water-meters, valves, hydrants. Standardization of system components means reducing costs, higher quality of service, and increased reliability. Material and spare parts management is therefore a specific and important activity in operation.

Water Supply Quality

The quality of the water supply source is an important factor influencing the operations and maintenance process and programme. If the water at source is clean and free of impurities then the required treatment will be minimal reducing the costs and complexity of the treatment system and thus reducing O & M requirements.

Water sources are fundamental to any water supply system and must provide the highest degree of reliability. This is why protection of sources against pollution is vital. Frequently, however, sources are not owned by the water company and management's control over them is therefore circumscribed. In such cases national or even international agreements are required to provide the necessary protection.

Surface water sources are particularly vulnerable. Where a river source flows through industrial or densely populated areas, maintaining quality is a continuous problem, accentuated by the risk of incidental pollution whose likely effects must be anticipated and planned against. When pollution does occur it may be necessary to suspend the intake source for a period.

Monitoring of surface sources is particularly important, not only at the intake point, but by regular inspections upstream. This is necessary so that quality problems can be assessed and if deterioration has occurred, action can be taken to protect supply, by whatever appropriate means, possibly by suspension of water abstraction. This demonstrates the need for adequate storage provision which is a basic requirement in the situation where water comes from surface supplies. Storage may be achieved in open reservoirs or underground by means of artificial infiltration. Protection of these storage resources and quality control are major management responsibilities.

The importance of protection and quality also applies in the case of reservoirs even when they are located in remote areas. Quality must be the criterion of whether or not, or to what extent, leisure activities are permitted on reservoirs.

Groundwater sources are less vulnerable to pollution than surface water. Catchment pollution is only likely to infiltrate abstraction wells after a protracted period. Nevertheless, protection zones around wells are necessary in which certain activities are prohibited or regulated. The flow of water in the direction of supply sources must be consistently monitored.

Some potential damage to groundwater supplies is very long-term, and in this respect even more serious, because once adverse effects are detected, there is no immediate counter solution. The concentrated use of nitrates for agriculture, for instance, has an accummulative effect on groundwater sources. It may take years for harmful build up of nitrates in the soil to become sufficiently penetrative to be detected, but once this has happened, there is no method of protecting sources. The neutralisation of nitrates in water supply by treatment from an affected source is extremely costly, and brings into question whether it is right that a water supplier, and therefore its customers, should have to bear the cost rather than agriculture which causes the problem. It is a vexed question, but clearly prevention is preferable, and more economic, than cure. For this reason monitoring and control in the catchment area of an underground source is of the utmost importance.

Underground sources may be extensive, but if they are to be exploited effectively and without detriment to other environmental factors, their levels and flow patterns should be monitored to gain knowledge of their character and fluctuations over a period of time.

If the water at source is not potable then some form of water treatment is required.Generally, a purification process comprises a number of successive steps. However, groundwater supplies may require little more than limited aeration and rapid sand filtration. In the case of a chemical-physical purification process, there may be elements such as flocculation, sedimentation, ozonization, activated carbon filtration, rapid sand filtration, disinfection and dosing with various chemicals.

In all circumstances it is necessary to guarantee that the clean water satisfies quality requirements in a continuous and consistent manner, and that production is uninterrupted. To achieve satisfactory

results in a purification system it is necessary to ensure that supply to it is provided in a consistent volume and flow. Intermittent fluctuations in flow to the installation disrupt the purification process and consequently affect the end quality of product.

In general, the aim is to purify the daily demand over a 24 hour period. To meet hourly fluctuations in demand, drinking water is stored in clear water reservoirs overnight. Even when the designed capacity of the installation is not in demand, the daily output must be achieved in a consistent and even manner. In a non-automated system this will require the attention of the operator who should not be tempted to keep the clear water reservoirs filled to capacity. The problem in these circumstances is that demand has to be estimated, and accurate assessments are normally the result of experience in manual systems, although where fully automated systems are in use they can be calculated statistically.

The aims of balancing quality and quantity cannot be achieved without sufficient and proper insight into the course of the process. Consequently, process control must stem from proper data collection. The frequency of various measurements may vary widely, from continuous through to the periodic of hourly, daily or weekly checks. Whatever the schedule, however, it must be very carefully designed.

Where a process is not fully automated, an installation is controlled by the operators on the basis of primary measuring data. This requires sufficient data about the automated parts of the process to enable the operator to monitor the operation and take any corrective action required.

As the process becomes more sophisticated, the range and variation of process data increases, sometimes to the point where it cannot easily be interpreted. In this situation there is a surplus of data that remains unused. This is an unsatisfactory, although not uncommon situation, and clearly it is necessary for all data to be processed if the performance of the installation and the effectiveness of the purification process is to be properly assessed. It is particularly important that any malfunctions or

deviations in quality are catalogued and analysed. Automation and information systems play an increasingly important role in optimising operations as the demands upon a system increase.

Special care and diligence is required when using chemicals in a purification process. Chemicals may be purchased 'off the shelf' from suppliers or as semi ready products. In the latter case, requiring blending by operatives, there are clearly increased dangers of mistakes, and it is not recommended other than where there are significant financial advantages and staff are qualified to produce the end product, or where there is no alternative because the required chemical composition is unavailable on the market.

The chemicals supplied must be checked against quality specifications for purity and composition. Adequate stocks to meet treatment demand must always be maintained, with sufficient surplus to maintain uninterrupted treatment in unforeseen circumstances, such as delivery problems with suppliers. Inevitably, the size of stock maintained will be governed by the suppliers' delivery capacity.

The principal problem in using chemicals is to meter accurately any dosage. Strengths must be adapted to achieve desired quality, and to maintain that quality in relation to quantity. The installation of reliable and accurate measuring and metering equipment is the precondition of sound operation, complemented by rigourous performance control and regular and intensive maintenance of equipment.

Whenever chemicals are used, there is always a problem of potential hazard to staff. Often chemicals may be injurious to health and this should always be taken into account when designing a system. Strict safety regulations should be enforced, backed by educational material to bring attention to the handling risks and to minimise accidents.

Supply and Distribution

The method adopted in operating a pumping and distribution system is largely determined by the size and configuration of the distribution system and the variations in level in the service area. Consequently, a wide variety of operating systems can be employed, ranging from simple manually controlled to fully automated and computer operated. The demand for water in any service area fluctuates

from hour to hour. Generally the minimum hourly use is not less than 1% of the daily use, while the maximum hourly use can be as high as 10%.

Optimum performance of a system - reservoirs, pumping stations, distribution networks - is needed to react to and meet these fluctuations. By optimisation is meant the ability to meet demand under predetermined pressure and to quality standards, but in the most economical way in terms of cost. These factors should be fully taken into account in the design of a distribution system. Nevertheless there is always scope for maximising results through sound operational control by staff. Where operational systems are manual, or only partly automated, the operator must be given clear guidelines on the methods of adjusting the pumping regime on the basis of available data. In the case of large pumping stations and extensive distribution networks, a vast amount of data is needed relating to volume and flow levels and energy consumption. Automation, computer aided operation and centralised control are increasingly applied to achieve the most effective and economic control of such large systems. It remains the operator's responsibility to monitor production and distribution, interpret the data, and adjust the system if necessary to keep within operating parameters.

When pumping stations rely upon electric pumps provided with power by outside agencies, it is necessary to make contingency plans for a possible breakdown in power supply. Standby generation independent of electricity is needed so that service can be maintained in the event of power failure, although this may be at a diminished level.

The necessary output capacity of such an emergency power system is determined by a number of factors: these include safety, availability of water from other sources, alternative pumping installations, and the economics of providing and maintaining such standby arrangements. In any event it would be unusual to provide cover to produce 100% back-up, and some 80% of normal hourly delivery is a more realistic target for emergency operation.

The distribution network of any water supply company normally represents some 75% of its total capital investment. In itself this statistic provides an obvious reason why it is prudent management and financial practice to maintain the network in the highest possible state of repair. It is equally important from the technical reasons of minimising leakage; containing interruptions to supply; and ensuring that quality is not affected during distribution.

Maintenance of distribution networks encompasses a wide variety of tasks. Apart from regular inspection of the network, including periodic checks of valves and hydrants, maintenance includes routine cleaning, rehabilitation and repair.

The regular cleaning of pipes is critical to efficient operation. Water being transferred through pipes, and the pipes themselves, may become polluted in several ways. Corrosion in old cast-iron pipes is common, resulting in a loss of capacity from rust formation, and rust particles being present in water through the tap. Other pollution arises from organic or bacteriological causes, or over long storage in the network. Various techniques can be applied to clean pipes: flushing with water; with water and air; by the use of foam balls; or by mechanical methods.

Normally, cleaning is carried out intermittenly according to need, but some policies involve systematic flushing on a regular basis where conditions demand such attention.

Pipes may also require replacement for technical, financial or qualitative reasons. If the reason is corrosion, a suitable alternative may be relining. This is usually applied where serious growth has occurred in old cast-iron pipes as a result of rust formation and lime deposits. Cement lining is widely used and can provide a pipeline with many years of additional serviceable life. The decision between replacement and relining requires careful study, and must take into consideration costs balanced against operational and technical factors. It is rarely a straightforward or self evident choice.

Repairing pipes through leaks or bursts is the most usual on-going maintenance activity. These faults develop as a result of many different internal and external stresses, and occur frequently in all

networks, both new and old. The first reaction is always to repair the fault as quickly as possible. Every company must operate an emergency system with standby crews available day or night with a back up of necessary equipment and materials. Advanced means of communication and specially fitted transport are invaluable in these circumstances.

Contractors are often engaged to deal with major bursts or leakages in larger mains which require the use of heavy equipment. In every repair there is a risk of pollution, and strict hygenic and operational codes for the workforce are needed to prevent or minimise this problem. The disinfection of pipes should be standard procedure after any repair.

Well functioning pipeline management is impossible without reliable pipeline registration: it is fundamental that management must know where its network runs and have details of its technical character. Registration records the geographical location of pipes, the valves, the hydrants, the connections, the sources of supply. It should also give topographic references and make it possible to show the location of pipes relative to the topography.

Pipe registration is still predominantly carried out by conventional methods requiring detailed plans and maps. However, increasingly it is being automated by means of digital mapping, giving instant and more accurate information than ever before.

Computerization

Computers play an increasingly important role in drinking water supply management. For many years they have featured in the administrative and financial management of water companies.

Nevertheless their employment in the technical and operational spheres of management has been slower in becoming established. Only over the last fifteen years has the use of computers for operational management been widely accepted.

There is no doubt that this trend will develop at a very rapid pace in the years ahead, for a number of reasons:

- demand for better quality, operational efficiency and reliability;
- the need for up-to-date reliable information to achieve those ends;
- the increasing complexity of purification systems;
- the need for simulation models for supply and distribution systems;
- centralisation, telemetry and remote control;
- laboratory data management;
- digital mapping of distribution networks.

The case for increased use of computers in new supply systems is difficult to dispute. However, it is much more difficult to assess the merits of introduction to existing systems, and this can only be done after thorough evaluation of individual circumstances, taking into account financial and technical considerations. But not only these, for computerization has considerable impact on personnel management and staffing in general.

It is important to remember that computers and computer systems are expensive. Any system must be geared in its degree of sophistication to the job it has to do. It is easy for management to become over enthusiastic and introduce systems with capacities far beyond the immediate needs of the role they are to perform. This can be a very costly error.

Organizational Aspects

Operation and maintenance not only require the appropriate technical resources, but also trained and qualified personnel. The management framework of the organization depends on the size and the complexity of the water supply system. The direct responsibility for operation and maintenance lies with the company's technical department. But the administrative department also has an important function. Administrative sections such as Personnel, Budgeting, Purchasing, Accounting, Consumer Relations, Public Relations, Billing, Administrative Automation have functional links with operations and maintenance units.

Generally the technical department is subdivided into at least two sections: Operations and Engineering. In that case Operation includes production, distribution, quality control and maintenance. Often these activities are organized in separate sections with their own responsibilities and competencies.

Equally as important as a good organization and a clear distinction between disciplines, is the availability of highly qualified and motivated people. The number of employees of different levels of education must be well-balanced. The best top management cannot fulfil its task if the middle management is under-staffed. Middle management needs sufficient and qualified personnel. Often external training is not sufficiently geared to the job requirements of a water supply company. Personnel have to acquire experience as well as knowledge within the company. Many companies have in-house training facilities or use jointly organised external training.

Most functions are carried out by in-house employees, particularly in the case of operational requirements. Certain maintenance activities are sometimes contracted out to third parties, for instance, the maintenance of specific electronic equipment. But the main consideration in the choice between internal and external maintenance must always be the aim of continuity and quality of the water supply. It is a situation where the cheapest is not always the best, nor the most economic in the longer term.

Practice of Operation and Maintenance Practices in the Asian Region

To obtain an assessment of the operational situation in the Asian region related to public drinking water supply, a questionnaire was sent to water authorities involved in 12 Asian regions. Completed questionnaires on 9 urban service areas from 7 countries were received. These concerned the drinking water supply of Shanghai, Taipei, Bangkok, Hong Kong, Singapore,
New Delhi, Bandung, Semarang and Surakarta.

A summary of the answers received from questions aimed at obtaining indications of the operation and maintenance situation is set out below:

- The percentage of 'unaccounted for' water lies between 20 and 43 (with two exceptions: Singapore 11% and Shanghai 7.7%). The lowest most favourable figure relates to the Shanghai water supply and can be regarded as related to that City's specific circumstances.
- All companies have metered terminals and all implement meter exchange programmes. In eight companies maintenance is carried out in-house; only one company contracted out these activities.
- Eight out of the nine companies have some form of corrosion control programme.
- All companies have laboratories. Eight of these laboratories are equipped with advanced analysis facilities.
- All nine companies observe the water quality standards of the WHO, national standards, or both.
- All companies operate maintenance schemes and carry out preventive maintenance. Five companies answered positively to the question about standby teams for operation and maintenance of treatment and pumping installations.
- Standardisation of spare parts for distribution systems has been introduced in all companies. This applies equally to treatment and pumping systems in all but one company.
- All companies clean pipeline systems periodically by flushing with water.
- All companies have renovation programmes for distribution networks.
- One company is involved in carrying out maintenance of household installations.
- All companies have active leak detection programmes.
- All companies use computers for technical and administrative purposes. Five out of nine companies use computers for pumping control. Computerised water treatment control systems are operational in four companies.
- All companies have emergency planning programmes.
- Meter reading periods range between one and four months.

- All companies organise internal and external training courses in operation and maintenance for their personnel.

The overall impression of the operation and maintenance practices of the companies which responded to the survey is one of positive commitment. Certainly there is clear evidence of efficient management at the higher levels; there is perhaps some suspicion interpreting variations in statistical returns, that this efficiency may not be translated into the lower management levels. Clearly there are favourable indications of continuing development in all companies which individually indicate positive prospects for the region as a whole.

Recommendations for Improving Operations and Maintenance

A water supply company is usually a public utility. More than in any other industry, a public utility has to give service to the people in the literal sense of the word. In this respect service from a water supply company means a continuous supply of drinking water in sufficient quantity, of safe quality and at reasonable cost. To meet those targets, four basic requirements are necessary:

- appropriate design of the water supply system;
- optimised operation of the system;
- intensive maintenance of the system;
- qualified human resources to manage the system.

None of these conditions is less important than the others. A water supply system designed with the utmost care, but ineffectively operated or insufficiently maintained, will fail sooner or later. Operation and maintenance are continuous activities which need qualified personnel and special and everlasting attention of the management.

The following recommendations are made as necessary prerequisites for the successful operation and maintenance of a water supply facility.

- The first step towards an effective operation and maintenance policy must be taken by the management. If the management does not accept a high priority for operation and maintenance, the quality of the water supply will inevitably deteriorate. Sooner or later, technical apparatus is bound to fail and water supply standards will fail with it. For that reason alone management must give their undivided attention to this aspect of their responsibilities. This is not so much a recommendation, as an absolute precondition.
- Operation and maintenance should have a recognisable and individual function with appropriate management status and support staff of qualified levels within an organization's management structure. An effective policy recognising O & M is impossible without management which is totally in sympathy with the company's task. Executive control should decide and establish policy and then allow managers to carry out the task.
- As a function Personnel is no less important than any other arm of the organization. Personnel should be competent; well trained; understand their task and authority and be motivated.
- Management should create a situation which enables them to employ competent and motivated personnel. The methods to achieve this include:
  - education and training; technical skill development;
  - clear definition of tasks and delegated authority to carry them out;
  - clear instructions and job descriptions;
  - clear administrative procedures;
  - availability of technical means;
  - progress consultation;
  - suitable working conditions;
  - internal company guidelines.

- Management and personnel must maintain dialogue to ensure compliance with defined rules and regulations and to effect modifications as and when appropriate.
- The financial and administrative management should be closely involved in the operation and maintenance tasks. Sound company operation depends upon a comprehensive and accurate registration and appraisal of all technical responsibilities and activities.
- Water charges should be geared to a level necessary for returns to cover the total annual capital costs and operational expenses. It is important that this income should be used exclusively for water projects and expenditure.
- Financial policy should take into account that initially new systems may cost more to operate because of teething problems. These exceptional costs should be included as part of capital installation expenditure. Once established, the operating costs of new systems should decrease with experience. They will however, start to rise again with the age of the plant and resulting need for increased levels of maintenance.
- The operational functions of a water supply company should embrace public relations and consumer relations responsibilities. These are required to keep the public properly informed about the company and its policies, as well as to establish a good rapport and reputation. The latter depends on the company supplying a good and reliable product, an important precondition of which is that operation and maintenance are carried out effectively to ensure minimum interruption of service and consistent standards.
- The importance of operation and maintenance should be taken into account at the design stage of a water supply system. This will influence both the choice of system components - abstraction, purification, transport and distribution - and the materials to be employed. Saving on initial outlay may increase maintenance costs subsequently. A basic aim should be to make the system as uncomplicated as possible and to use materials for components of first class 'maintenance friendly'

quality. Experience supports the need to keep individual components and functional units separate from each other for ease of maintenance or repair. Initial costs should not be the sole or most important criterion in the selection of units.

- Genuine consultation between planners, designers and operation and maintenance management is needed to realise a design which is optimally geared to economic use, practical operation and financial return. Gravity systems are preferable in general, but if not feasible, electrical supply is preferred to other alternatives.
- Generally speaking it is recommended to apply 'the best available technology' in order to achieve an optimum blend of 'appropriate' and 'advanced' technology. A choice should reflect an assessment based on practical experience of O & M requirements from different countries and under varying conditions.
- An analysis of all technical components of the water supply system and their reliability and life expectancy should be drawn up to ensure which and what quantity of spare parts should be available in order to guarantee the continuity of water supply.
- Management should pay specific attention to collecting and processing relevant data on the full range of company responsibilities and its performance. In the specific field of operation and maintenance a clear insight should be obtained into the performance of:
  - water purification process;
  - production;
  - water supply;
  - water quality.

The assimilated data should be processed into easily understandable periodical reports for various levels of management and executive personnel. Dependent on need, these could be daily, weekly or monthly reports.

- Each company should have at least one laboratory with appropriate facilities and qualified personnel required to adequately manage and control purification processes and to periodically test the water quality against the set primary quality standards.
- The water should be sampled regularly both at the source of the distribution system and in the distribution system itself. For this purpose schedules are required indicating the sampling locations, sampling frequency and the parameters to be analysed.

Conclusions

The following most important considerations should always be taken into account when developing a sustainable O & M policy:

- the essential basis for long term and smoothly operating supply systems is sound initial design;
- good design should not be assessed on the basis of initial financial outlay. Many other factors should be taken into account including the important aspect of ease of future maintenance at reasonable cost;
- positive support at executive level in allocating necessary funds and enthusiasm at managerial level for devising and implementing O & M policy are vital to its success;
- a precondition for the protection of a water supply system is good operation and maintenance practice;
- operation and maintenance tasks require a well structured organization with trained and qualified personnel;
- preventative maintenance to achieve optimum efficiency in a supply system is essential for its continuous success;
- comprehensive water quality monitoring is a vital element in operating efficiency;
- data collection on the day to day production and distribution process is a basic need for good operation and maintenance;

- effective maintenance of the distribution system is not possible without network mapping;
- adequate spare parts and appropriate equipment are a prerequisite of proper maintenance;
- effective operation and maintenance are not attainable without financial and administrative support and supervision;

Information obtained about the level of drinking water supply in 9 urban areas in the Asian region gives reason for optimism for future development. It is expected that in the long term this situation will have a stimulating influence on the development of service levels in rural areas of the countries involved.

Operation and maintenance should have well defined aims and objects and be established as a management function in its own right. Nevertheless it should be an integral part of the overall management strategy of the water undertaking, complementing other management responsibilities. Its function is to contribute to the effective and economic management of the organization with the result of providing a safe consistent water supply service at the most economic price, to as many consumers as possible.

The practical operation of maintaining service, monitoring standards, and providing water at consistent levels is greatly facilitated by regular and planned maintenance. The level and degree of this maintenance, the policy of replacement of new parts, the assessment of when the cost of maintenance reaches uneconomic levels compared with replacement expenditure, are management decisions requiring experience and technical knowledge.

It is important for the success of any policy that the best available technology is selected: not necessarily the cheapest; not necessarily the most expensive; not necessarily the most technically advanced. But the most appropriate to prevailing local conditions and to the task that it has to perform.

This requires consultation between managers of technical and financial disciplines, and also those who will have responsibility for operating the system. It means being able to consider all available alternatives, and not being restricted to any particular recommended solution.

The growth in urban cities world wide is an unrelenting problem. Experience proves that improvement in facilities to ease existing problems tends to attract an even larger population through immigration from rural areas, and increased birthrate and lower mortality through better health and hygiene. Consequently planned improvements quickly become inadequate. This trend is increasing and negates the theory that improving rural facilities in itself discourages movement into urban areas.

Management strategy should adopt the complementary aims of improving and more efficiently utilising existing facilities and resources including manpower, and where necessary, expanding services and systems to improve inadequately served areas and to bring supplies to new ones.

These aims demand the interaction of a wide range of individual management responsibilities and technical skills, since none in isolation can achieve significant improvement. The development of technical capacity will not be possible without sound financial policy and management. Such development on an institutional scale depends on these two spheres - technical and financial - being treated with equal emphasis and priority.

The management thrust to achieve improvement and development should be directed towards:

- institutional development and capacity improvement, both technical and financial;
- information exchange and dissemination of country-wide experience, research and models to reach all levels;
- undertaking applied research, especially in the area of reducing water loss, conservation and recycling, and developing suitable models for delivering basic services to low income communities;
- user involvement, community participation and partnership with other interests, including the private sector;
- choice of technology and level of service based on willingness and ability to pay rather than lower cost;

- the underlying defect in many areas is weakness of management capability, although as already stressed, the returns show that in the Asian cities which responded, management at the higher levels was impressive. Nevertheless training of staff should be a consistent and important exercise and is fundamental to achieving the required management goal.

Within the context of institutional planning the following are important:

- the establishment of programmes for improved, systematic operation and maintenance practices;
- improving metering, billing and collection;
- developing and strengthening of units for water quality surveillance including setting up laboratories;
- development and strengthening of units for setting standards, promotion of local materials and methods and quality certification through testing;
- setting up special units within water supply utilities to work with community organizations;
- setting up systems for exchange and communication of country experiences and practices and sector information in general at all levels and the promotion of in-service training.

Policy objectives within an overall strategy are important, but their success or failure will depend on the correct technical selection of equipment and systems to achieve the end economically and with minimum recurring problems.

Management strategy should also take into account the growing environmental considerations which are becoming increasingly important world wide. Designs should be chosen which minimise waste and are most economic in the use of chemicals whose disposal could affect the environment.

In the context of broad environmental management there is little doubt that the future will require an integrated management approach embracing the problems of water supply, sewage disposal, sanitation, and solid waste disposal. This is inevitable if the problems of pollution are to be contained and the world is to enjoy a more wholesome living environment.

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THE WATER LOSS CONTROL PROGRAMME FOR TIJUANA, MEXICO

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Tijuana, Mexico

Introduction

The "Comision Estatal de Servicos Publicos" de Tijuana Tecate (CESPTT) has the responsibility for operating and maintaining the water supply system for Tijuana, Mexico.

The CESPTT is facing critical problems regarding the operation, maintenance and management of the water supply facilities. The water supply system is undergoing rapid expansion and suitable operation and maintenance procedures need to be developed and implemented to ensure the efficient and effective delivery of water.

The Tijuana water supply system faces two major problems. First the source is located far from the city and thus necessitates costly primary supply pipelines and facilities. Also the population growth rate in Tijuana is very high, higher even than the national average.

Unaccounted-for water is a major problem in Tijuana and is estimated to be in excess of 40%. This represents a considerable financial loss in revenue for the CESPTT. In order to reduce unaccounted for water losses to an acceptable level, a "Losses Control Programme" has been developed by the CESPTT.

This paper describes the major objectives and components of this programme.

Losses control programme

The overall objective of the programme is to reduce unaccounted-for water to a level of 25% by the 31 December 1995.

Specific objectives include:

- To establish an information system which will allow the continuous monitoring of water losses.

- To reduce wastage and excessive consumption in the various parts of the water supply system (i.e. in treatment, transmission and distribution).
- To develop and implement effective billing and collection procedures based upon realistic consumption rates.
- To develop and implement an operation control system which will improve the efficiency and effectiveness of the water production and distribution processes.

A number of deadlines and targets have been set in the programme. These include:

(1) The implementation of a network survey service by January 1990.

(2) The completion of an updated user registration system by July 1991.

(3) The implementation of a metering system capable of measuring 100% of the produced water and 80% of the consumption by September 1991.

(4) The reduction of water losses to 35% by December 1991.

(5) The reduction of water losses to 30% by December 1992.

(6) The development of a model to simulate the water supply system by December 1992.

(7) The identification and control of the various causes of water losses by December 1993.

Programme implementation

The multidisciplinary nature of the programme makes it difficult to identify a unit presently within the CESPTT capable of implementing the programme. Therefore a special unit answerable directly to the Director-General of the CESPTT should be established to direct the Losses Control Programme.

Although system design and new constructions are not directly linked to the immediate problem of unaccounted-for water, they may affect future water losses if inappropriate designs and inefficient systems are built. Therefore the losses control programme should have an input into systems design and system expansion. This should include the establishment of criteria and standards to ensure better designs and construction of future systems and enhanced quality control for materials and equipment.

An improvement in support activities such as planning, human resources development, social communication, financial administration and transportation will be an essential requirement for the successful implementation of the specific projects envisaged under the Losses Control Programme.

These support functions are to be strengthened under the Institutional Development Programme currently underway in the CESPTT.

Twelve specific projects are included within the general framework of the Losses Control Programme. These include projects on:

(1) User registration

(2) Metering

(3) Billing and collection

(4) Integrated system for collecting data on commercial use

(5) Technical inventory of installations and equipment

(6) Mapping

(7) Network survey

(8) Macrometering

(9) Operation control

(10) Leakage control and maintenance of the pipe network system and house connections

(11) Maintenance of facilities and equipment

(12) Electromechanical maintenance

It is difficult to assign priorities to the projects as they are in fact interlinked and interrelated. To have an impact on system performance, and to reduce water losses the projects should be implemented in concert and not in isolation.

It is anticipated that the implementation of the projects will result in:

(1) The creation of sustainable information systems capable of delivering basic reliable data on system performance. The projects which will influence this include, Network Survey, Macrometering, Mapping, Metering, Operation Control and Integrated System for Collecting Data on Commercial Use.

(2) The establishment of corrective actions for the reduction of water losses. The related projects are: Metering; Leakage Control; User Registration; Operation Control and Billing and Collection.

(3) The implementation of actions which will minimize water losses. The respective projects are: Maintenance of Facilities and Equipment; Operation Control; User Registration; and Electromechanical Maintenance.

The undertaking of some selected projects involving the commercial use of water, for example, metering, billing and collection will generate revenues in the short term which can be applied to finance the implementation of other projects and activities.

Summary

Unaccounted-for water in Tijuana is currently at the unacceptable level of 42%. The proposed programme intends to reduce unaccounted-for water levels to 25% by December 31, 1995.

At the present time, the lack of adequate basic data on system performance makes it impossible to identify the reasons for water losses. There is an urgent need to collect reliable data to determine how and why water losses are occurring.

Preliminary studies suggest that commercial losses, i.e. those directly attributable to inadequate billing and collection procedures and financial management are greater than the losses due to leakage and the physical performance of the system.

It is anticipated that the implementation of the Losses Control Programme will lead to a reduction in water losses, a lowering of system operational costs, increased revenues, improvements in service levels, an enhanced image for the CESPTT, increased productivity and a higher level of user satisfaction.

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