1984 AFRICAN WATER TECHNOLOGY CONFERENCE

KENYATTA CONFERENCE CENTRE, NAIROBI.

10th-13th APRIL 1984, 10-13 AVRIL 1984.

The international conference for the water and sewage treatment industries of Africa.

Congrès africain de la technologie de l'eau

PAPERS PRESENTED AT THE

SECOND AFRICAN WATER TECHNOLOGY CONFERENCE

TUESDAY 10TH APRIL AND

WEDNESDAY 11TH APRIL 1984

HELD AT THE

KENYATTA CONFERENCE CENTRE

NAIROBI, KENYA

ORGANISED BY AFRICAN WATER AND SEWAGE JOURNAL

EDITED BY: RON GRACE

CONFERENCE PROGRAMME

Chairman:	Peter G. Bourne, M.D., President, Global Water, Washington D.C., U.S.A.
Vice-Chairman:	John Pickford, WEDC Group Leader, Loughborough University of Technology, U.K.

DAY 1, TUESDAY 10 APRIL 1984

09.00 - 09.30	Official opening of the Conference by the Hon. J.J. Nyagah, E.G.H., M.P., Minister of Water Development; Kenya.
09.30 - 10.00	Address by Mr. H.K. Rotich, Director of Water Development, Kenya.
10.00 - 10.10	Opening remarks by Peter Bourne M.D., Chairman of the Conference.
10.10 - 10.40	<u>Paper 1</u> Project preparation-financing, management and cost recovery. Tauno Skytta, Ahmed Nur and Philip Owusu, World Bank.
10.40 - 11.00	Coffee.
11.00 - 11.30	<u>Paper 2</u> Water auditing. Charles Hurst and Dr. Jerry Bryan, Thames Water Advisory Service, London.
11.30 - 12.00	Discussion
12.00 - 2.00	Lunch
2.00 - 2.30	<u>Paper 3</u> Organising for maintenance in water supply project implementation. Ebbo Hofkes, Programme Officer, IRC, Holland.
2.30 - 3.00	<u>Paper 4</u> Implementation of rural water supply project in Central Region, Ethiopia. P.H.W. Bray, Sir M. MacDonald and Partners U.K.
3.00 - 3.20	Tea
3.20 - 3.50	<u>Paper 5</u> Water supplies in the Jonglei area - a changing strategy.
3.20 - 3.50	J.J. Wadley and D.I. Aikman, Babtie Shaw and Morton U.K.

3.50 - 4.20 **Paper 6**

The role of UNICEF in support of water and environmental sanitation programmes in Eastern Africa.
John Skoda, Eastern Africa Regional Advisor, UNICEF, Nairobi.

4.20 - 5.00 Discussion.

DAY 2, WEDNESDAY 11 APRIL 1984

10.00 - 10.30 **Paper 7**

Management aspects of project implementation in developing countries.
J.D. Williams, Howard Humphreys and Partners.

10.30 - 11.00 **Paper 8**

Emergency works for augmenting El Hawata town supply in Eastern Sudan.
Peter Stern, Gifford and Partners, U.K.

11.00 - 11.20 coffee.

11.20 - 11.50 **Paper 9**

Implementation of handpump schemes for rural water supplies in Africa.
David Grey, Regional Project Officer, Nairobi and Otto Longenegger, Regional Project Officer, Adibjan, Ivory Coast - UNDP/World Bank rural Water Supply Handpumps Project.

11.50 - 12.30 Discussion.

12.30 - 2.00 Lunch.

2.00 - 2.30 **Paper 10**

Implementation of sanitation projects in developing countries.
Jim Wilson, UNDP, Botswana.

2.30 - 3.00 **Paper 11**

Urban low cost sanitation implementation.
John Ashworth, Halcrow-Balfour Ltd, UK.

3.00 - 3.20 Tea.

3.20 - 3.50 Illustrated talk by Ephraim Chimbunde of Ministry of Health, Harare, Zimbabwe.

3.50 - 4.20 **Paper 12**

Professional and popular participation in African water technology.
John Pickford, WEDC Group Leader, Loughborough University U.K.

4.20 - 5.00 Discussion.

5.00 Conference ends.

ORGANISER'S NOTE

Papers 1, 9 and 10 were not available at the time of printing so they could not be included in this bound volume. However, the papers will be supplied, separately, at the time of registration.

<u>PAPER 2</u>

A WATER AUDIT

BY

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and

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1 INTRODUCTION

1.1 GENERAL

A water undertaker's prime function is to provide adequate potable water as efficiently as possible. Similar criteria should apply to any other functions such as sewage disposal and land drainage. Since all services are given from a monopoly position, the efficiency and cost effectiveness of the service will inevitably have financial implications on consumers. Expensive and inefficient services will be reflected in the competitiveness of industrial consumers.

What is a Water Audit?

How does it compare with a conventional audit which is primarily concerned with the examination of financial accounts? Money is an accepted base when comparing many parameters and great emphasis is placed on the vital need for accurate financial data, but how much emphasis is placed on the validity of the sources of this data?

Most organisations have a statutory requirement to have accounts audited. If all the ancillary functions could similarly be examined periodically then the results of the audit would be more meaningful.

Normally a thorough investigation of an undertaking is conducted only before the introduction of a major capital scheme. The requirement to provide additional water will usually be as a result of anticipated or actual increase in demand.

Before such a new scheme is considered, it is suggested that it will be more cost effective in the short and long term to optimise existing assets, reduce unaccounted for water to an economic minimum, improve operational efficiency and ensure that revenue collecting procedures are working correctly.

A Water Audit is, therefore, defined as a financial/engineering audit of a water undertaker.

Once the efficiency of the organisation progresses to the point where reliable management monitoring data becomes available, this will provide the basis on which to plan any extensive major capital schemes and ensure that facilities are available to utilise the additional capacity and maintain the investment.

It is, therefore, essential that a full technical/financial analysis of any undertaking is carried out at an early stage and that as soon as possible the necessary improvements are made to the running of the organisation to provide and maintain the data on which the development of services will depend.

1.2. OVERALL MONITORING

Without monitoring there is no control.

A financial audit is one approach to monitoring an organisation, but it will not go into the engineering implications in enough detail. The basis of the information may be suspect. For example how often are the output flow recorders at a waterworks volumetrically calibrated after they have been initially commissioned, or when a water shortage occurs is the true reason for it identified in enough detail? A further example refers to the accuracy of the amount of unaccounted for water - a very important proportion of the water produced - which is sometimes expressed as a percentage or a volume. How much of the unaccounted for water is attributable to defective metering, illegal connections, inaccurate meter reading and billing systems or leakage? If the inefficiencies can be identified then corrective action can be taken, and the picture becomes clearer.

1.3 AIM OF THIS PAPER

Having clarified what a water audit is, and why it is necessary, this paper will deal with the subject in general terms and explain how such an audit should be conducted. It will not deal with any specific examples of inefficiencies and it is not a case history of any specific organisation.

2. FINANCIAL/ENGINEERING RELATIONSHIPS

2.1 REVENUE SOURCES

Efficient collection of revenue is one of the most important functions of any organisation, yet it is so often neglected. Every businessman is aware of the strains that cash flow problems exert on the organisation.

The prime method of collecting revenue is by billing for potable water and sewage disposal. This will rely on an efficient system for prompt meter reading (where consumers are metered) and billing. A well organised meter reading system can also provide information to identify areas of unaccounted for water, of which a major proportion will be leakage.

Where not all consumers are metered then some form of levy (or rate) will be charged.

The procedures for billing and collection should be carefully established, especially the permissable priod to pay before drastic action is instituted. This is an area where consumers can all too easily be allowed to build up considerable debts before the undertaker takes corrective action.

Rechargeable works may form a relatively small proportion of income - and payment in advance is always advisable.

Debt collection procedures can be slow and cumbersome, but often if adequate attention is given to setting up correct procedures, with the minimum amount of paperwork, then a prompt and efficient system can operate, and will thus overcome most of the problems before they arise.

It is most important that a monitoring system must be built into the procedures if the adopted method is to remain efficient.

2.2 BILLING AND COLLECTION

Where consumption is measured by meter, then consumers are billed based on meter readings for both potable water and, normally by inference, for the sewage treated by the undertaker. An efficient meter reading and billing system is essential, not only because it can ensure maximum receipt of income, but also because the information collected has other uses in the formation of tariff structures, assessing unaccounted for water and demand forecasting.

Yet how often is the meter reading and billing system overhauled? How clear are existing procedures? How does this part of the organisation's function dovetail into the engineering systems?

The meter reading and billing procedure is one of the first areas to be closely investigated to ensure:

a) meters are correctly read;
b) the recording system is adequate to enable maximum benefit from the meter reader's periodic visit;
c) transfer of data from recording system to billing system is accurate;
d) information gathered is optimised for other functions such as identification of stopped meters, metered consumption bands, assessment of unaccounted for water and indication of potential leakage on consumers properties;
e) bills are dispatched on time;
f) the allowable payment period/cut off procedure is carefully monitored.

The meter reading and billing system can produce a wealth of useful information if it is maintained at an efficient level, and it is designed to dovetail into engineering functions; for example, the meter reading areas should correspond with distribution/supply zones and/or waste area zones.

Projected and actual income should be carefully monitored to assist with cash flow and as a routine check on the system. The projected billing should be updated every month to take into account the monthly production figures. This, of course, assumes that production is monitored and unaccounted for water has been fairly accurately assessed.

2.3 POTENTIALLY RECOVERABLE INCOME

This is defined as that part of income that, for a variety of reasons, has not been collected. It will be made up of revenue and capital reimbursement.

The revenue will be lost as a result of illegal connections, stopped and slow meters, (that is those that under-register), oversize meters, leakage, and non-existent water production. Where water shortages exist, the financial losses will be greatest. The number of illegal connections can only be reduced by detective work. Often oversize meters are installed because employees fail to understand that the correct size of meter is not necessarily the same diameter as the pipework. Where there is no proper procedure for early identification of a stopped or slow meter, then months can pass before rectification is carried out.

Quite often the reimbursement system adopted, and agreed, by a financier or donor is clearly laid down, and the correct procedures for award of contracts, payments and variations of price have to follow exactly the agreed procedure. Many organisations obtain only 80% of the capital expended because the procedure for claiming the money has not been correctly followed. Where contractual arrangements have been made to pay the whole or part of the payments in foreign exchange, then this can have serious contractual repercussions. Contractual problems also occur where the paperwork is not processed fast enough to enable payment to be made within agreed contract dates. The losses to an undertaker can be considerable. Again the ability to maintain the correct procedure will depend on good monitoring systems. These must be properly instituted and maintained.

2.4 TARIFF STRUCTURES

The data to maintain an acceptable tariff structure should be obtainable from the summary of the meter billing system. Consumers should be classified and consumptions categorised within band widths. It is therefore essential to incorporate this facility within the procedure, when the summary monitoring data is formulated.

The tariff structure can be formulated in numerous ways to obtain the required income. It can also be used to control demand and in some cases this may be the most cost effective method, since additional revenue can be used to subsidise the poorer members of society.

It is clear that unless these functions are considered at the time the procedure is designed, then these financial statistics cannot be used to provide engineering information.

2.5 IMPROVEMENTS

It is clear from preceeding sections that the financial and engineering functions of a water undertaker are inter-related. However, rarely are they considered together.

If adequate income is not generated, then the engineering functions cannot perform as they should. This will lead to delays in carrying out necessary works at the expense of the consumer.

The efficiency of the organisation should be maintained at a peak and periodic water auditing will enable this goal to be achieved.

3. OPTIMISING RESOURCES

3.1 IDENTIFYING SYSTEM LIMITATIONS

Water shortages occur when demand exceeds supply. There may not be adequate installed measuring equipment to enable a true assessment to be made of where the problems occur.

Relatively minor capital works in the appropriate places can be the quickest and most cost effective method of overcoming the problem. The obstacle in achieving this objective may be that the necessary calibrated flow and pressure measurement equipment is not readily available, nor are there qualified trained staff to conduct the tests and analyse the results.

The water lost through leakage is taking up valuable system space which, considering the equation for headloss compared with flow, can have a dramatic effect on adequate supply pressures at peak demand periods. A good deal has been written about unaccounted for water, sometimes expressed as a percentage of the output (we assume!), but the accuracy of the numerator and the denominator are very questionnable.

3.2 PRODUCTION CAPACITY

Waterworks are designed to have a long operational life. Modifications are often made to a works during its lifespan. Extra production capacity may well be possible at a small additional cost, but identifying the areas for improvement may necessitate a full hydraulic analysis of the works. In a works where many of the meters and gauge readings are suspect, then appropriate calibrated equipment is essential for qualified personnel to conduct the analysis.

The quality of treated water must also be fully checked, and analysis made to ensure adequate control over future production.

3.3 DISTRIBUTION CAPACITY

Major improvements can be made to a distribution system by better utilisation of existing resources. This can be achieved by examining, among other areas:

a) the restrictions in the system, that is pipes with high headloss, orifice plates, and so on;
b) re-zoning;
c) combining pumping and distribution mains, provided due consideration is given to surge and pump controls;
d) maintenance of apparatus.

The best way of analysing the distribution system is to conduct full field tests to identify existing parameters of flow/pressure relationships and then carry out a theoretical hydraulic analysis based on correct parameters. The field tests are normally the most difficult part of the exercise, but may well prove a very cost effective exercise if the tests are conducted by qualified personnel with appropriate calibrated equipment.

For various reasons, this part of the work is sometimes not carried out. As a result, the restrictions in the network are not clearly identified, and unnecessary expenditure is incurred.

3.4 OPERATIONAL EFFICIENCY

Indicators of problems within the operational functions of an organisation will be evident from consumer complaints and breakdowns.

Optimising the utilisation of men, equipment and transport is a fundamental management function, but setting up an efficient organisation and maintaining it at an acceptable level is a difficult task. Improvement areas may be identified but making changes may not be practical if the improvements cannot be maintained. However, there is no reason why the simple cost effective benefits should not be identified and improvements made where appropriate.

The assessment of the efficiency must be based on financial data since this is a common factor, and it should be possible to extract financial figures from the accounts. The costs are one area to examine but other techniques must be used.

Whenever a waterworks is commissioned the manufacturer supplies a set of maintenance manuals. Although they contain all the essential details, the manuals may not be presented as a planned maintenance system. This may not be the job of the plant supplier, but if the new installation is to continue to work satisfactorily then the personnel who will maintain that works must be trained in a maintenance system to <u>prevent</u> breakdowns.

A good, simple planned maintenance system is essential to any organisation, especially in a developing country, but how often do you see one that works? A tremendous amount of drive and energy is required to start such a system off - but the rewards are well worth the effort.

In a developing country, planned maintenance is essential since the workforce may not be accustomed to large mechanised treatment works and it is therefore most important to set up a system for the supervisors and men, which will ensure that expensive equipment is properly maintained.

The difficulties that can arise in setting up a system are as follows.

a) <u>The human element</u>: men like to be free! If for years the personnel have not been disciplined to laid-down procedures, there will be an understandable resistance at all levels.
b) <u>Plant information</u>: there may be little available information on the existing plant so this will have to be collected together.
c) <u>Crisis situation</u>: planned maintenance will reduce the crisis situations dramatically, but it will need to be implemented when the crises are occurring. It is likely that nobody will have time to sit down and prepare the necessary documentation. This is where it is desirable to bring in a qualified, down-to-earth specialist team who can devote their full time to setting up the system. For success the specialists will have to be good psychologists!

Before expressing the benefits of planned maintenance, maybe we should clarify the basic system.

What is planned maintenance? A system which simply ensures that the required maintenance is carried out at the correct time.

A simple system could operate as follows. On the wall of the supervisor's office is a board with 52 pouches. Into each pouch is a card which has the number of the jobs to be carried out that week. The job numbers refer to the plant and service required.

The History Card for the particular item of plant is selected together with the detailed maintenance procedure for that particular service.

The procedure sheet will show the man which spares and tools he will definitely require. The man then goes to do the work which is set out on the procedure sheet. The man completes the work and takes any readings, notes the information on the history card and returns it and the procedure sheet back to the supervisor. This is then scrutinised by the supervisor and any action taken.

Now such a system is actually making it easier for people to carry out their work. In a developing country, the skilled labour force will be limited in numbers. If the work that they have to carry out is simply set out stage by stage there is a good chance that it will be carried out properly.

People find it difficult to set up procedures - and notice how difficult it is to maintain them because human beings do not by nature like being closely supervised.

The spin-off benefit of the planned maintenance will be:

a) the length of time to carry out services will decrease;
b) a good record of plant reliability is available together with the true cost of carrying out the maintenance;
c) the ordering of spares should improve;
d) management information data becomes available.

It all appears so simple but, as stated earlier, it can be very difficult to set up. Planned maintenance can be applied to many other areas such as trunk main surveillance, routine checking of records plans, mains flushing, waste detection, meter maintenance, and so on - any jobs which should be carried out on a routine basis.

These are precisely the areas into which more investment should be channelled and it is essential that such systems should be set up because, although you may train people, if they are not then equipped to make full use of their training, that training will be of little long term value.

It is very unlikely that there will be the depth of middle management in a reasonably sized water undertaking in a developing country compared with one of similar size in Europe. The water demand, the distribution system, the number of meters, and the number of consumers will all be increasing daily. Ideally the systems and control for running the day to day affairs should be channelled through a well-organised control room in order to make best use of those few experienced people available. By this method better use can be made of manpower and transport facilities.

The control room should contain a radio, telephones and magnetic display boards (a thin sheet of flat galvanised steel and small magnets to attach the information). Every vehicle should have a two-way radio. Before explaining how the system could work one may ask why there is the need? One has to consider the following.

1. The transport and fuel may well be in short supply so they must be closely controlled.
2. Since most of the excavation and backfilling work will be done manually, a large number of people will have to be transported.
3. The trained personnel will be limited and they will be dealing with an ever increasing workload. If the best employees are on site most of the time, they are not being effectively used.

4. Between 80 and 90% of consumer complaints can be analysed on the telephone - especially if a systematic questioning procedure is used. If the supervisor can instruct the nearest vehicle to the complainant to conduct any necessary tests, then using these results together with data available in the control room he will be able to solve nearly all of the complaints without leaving the control room. He can also organise any necessary action.

To set up such a control system needs the full backing of the management and this will require experts to be brought in for advice on collection and co-ordinator of data, to propose a suitable system to implement it, and maintain it. This would all have to be done with the co-operation of the middle management, who would also be busy with their day to day work, but the savings and improvements in consumer services can be enormous.

4. UNACCOUNTED FOR WATER

4.1 GENERAL

This is a very topical subject and many figures are bandied about, mainly in percentages. But how accurate is the basic data?

Unaccounted for water is defined as the difference between the total quantity of water put into supply and the total quantity of water passing through consumers' meters. By definition, unaccounted for water depends upon information of production and consumption of water, any errors within both the methods of measurement can result in gross over or under estimates. To obtain any reliable figures, it is important to know the accuracy of the fundamental data.

Where the majority of the consumers are not metered then the only way to make a reasonable assessment of unaccounted for water is to use nett minimum night flows, that is minimum night flows less known night consumption.

Unaccounted for water is made up of leakage on the undertaker's side of the consumers' meters, water not metered, illegal connections, and errors in metering.

Where there are water shortages, and all consumers are metered, this forms a large loss of revenue to the authority. It is therefore a very important lost asset.

4.2 PRODUCTION FIGURES

Ideally production flowmeters should be volumetrically recalibrated at reasonable time intervals - but this is rarely carried out. Often instruments are converted to different units and re-ranged and the resultant flow figures rely upon everything being carried out correctly. Flow instruments are always calibrated dry, that is, a known artificial differential pressure is put across the instrument and the calculated flow compared with the recorded figure.

4.3 CONSUMERS' METERS

There are mainly two types of meters used, one works on the semi-positive displacement principle and the other on the single or multi-jet principle. At low flows, with age, the semi-positive displacement meter usually records less than actually passes, and the inferential meter records a greater quantity.

Provided leakage on the consumer's side is kept to a minimum, the inaccuracy at low flows will not make much difference to the unaccounted for water. If, however, a property is supplied with water from a roof tank and the ball valve does not have a positive rapid shut off, then the inaccuracy at low flow rates can make a difference.

Most apparent inaccuracies are caused by the variability of meter reading periods and meter records.

4.4 ILLEGAL CONNECTIONS

One of the most effective ways to locate illegal connections is to update the meter reading and billing system. This exercise should involve visiting all properties. Provided the investigators are honest, and careful checking takes place, then most illegal connections should be identified.

In a badly organised meter reading and billing system, accounts are lost. The system should be designed so that once a property has a water supply, the details are never mislaid.

4.5 LEAKAGE

A system of monitoring minimum night flows should be instigated to give an immediate indication of likely levels of leakage, irrespective of whether all consumers are metered.

Once an assessment has been made, the leak location exercise can be conducted in the selected areas.

There are several degrees of leakage control that involve leak detection and location. It is not the purpose of this paper to go into the subject in any detail. However, a reasonably accurate assessment of the highest leakage level must be made and the areas where it occurs identified so that a cost/benefit analysis can be made. To do the analysis properly requires experienced personnel and equipment to carry out the on site tests.

The secret of efficient leak detection depends upon well trained personnel, the best type of appropriate equipment and good control. It is essential to set up a monitoring system to ensure that the benefits are accurately logged.

Waste detection can be a soul destroying job and hence not only is it essential to identify savings, from the financial viewpoint, but also to boost morale. If few benefits are recorded it is not surprising that interest can soon wane. It is essential therefore to set up good procedures not only to carry out the leak detection exercise efficiently, but also to obtain good records of the results. Unfortunately, too often good records are kept of expenditure and not enough data on results.

5. MONITORING AND PROCEDURES

5.1 MANAGEMENT INFORMATION SYSTEMS

It all starts from the top.

If motivation is to be maintained within an organisation, it is essential that a good simple management information system is implemented and maintained.

As part of the audit, careful attention should be paid to how various data can be summarised to present a clear objective record of progress in improving efficiency and then maintaining it.

Earlier it was stated that meter reading areas should correspond with distribution areas. By designing the system in such a way, valuable information can be produced and logged to allow a clear picture of inter-related functions. In the case mentioned, it will produce, among other data:

a) an assessment of unaccounted for water for each distribution area;
b) allow minimum night flows into distribution zones to be compared with the assessment of unaccounted for water;
c) produce area demand figures which can be used to overcome normal distribution problems and assist with forecasts;
d) record the number of leaks located within each distribution zone;
e) cost of waste detection per distribution zone compared with monthly unaccounted for water figures and minimum night flows.

As shown, the systems should be designed to give clear integrated data to allow adequate control to be exercised.

5.2 PROCEDURES

In few organisations does one find an up to date procedure book. It can be a valuable asset since its preparation will ensure that existing systems are overhauled and their replacements correctly documented. Modifications can easily be incorporated.

It is a valuable management tool since no longer can staff complain that they do not know!

Setting up a procedure system requires an experienced person with adequate organisational training to be able to identify areas for improvement. The maintenance is equally as important.

So often is incompetence in an organisation caused because a change of staff results in different methods being adopted.

6. DEMAND FORECASTS

6.1. CONSUMER USER CATEGORIES

If there is a large variation in living standards across the range of consumers supplied, then it is important to quantify the per capita consumption in the different user categories.

There are various factors that will determine consumers basic consumption needs, which include income, water fittings, climate and cost of water. The peak annual demands may well be caused by garden watering and this should be assessed separately.

The only way to obtain this information may entail examining every account, but if there is no urgency to obtain the data, then the categorisation should be designed into the meter billing computer programme. If a computer billing programme is not used then the data can very quickly be slotted on to a printed sheet which takes into account the meter reading period.

Since consumption patterns can vary considerably, then it is essential to extract information in this detail to ensure that an economic design is produced and existing resources are optimised.

The data will form the basis of the water management of the authority.

Garden watering can be controlled either by legislation and/or price sensitivity. This use cannot be classified as essential and, if uncontrolled, the supply of water for this purpose should be carefully considered. Shortly after a new scheme has been commissioned, garden watering may be encouraged, but as essential demand increases, it may have to be controlled.

6.2 POPULATION GROWTH AND INDUSTRIAL DEMAND

To formulate a future demand growth curve the anticipated population growth must be taken into account.

There are various factors which will have to be considered and adequate allowance made for the variable future requirements. No prediction is ever exactly correct, and therefore, a flexible approach will have to be considered.

6.3 FINANCIAL IMPLICATIONS

It has been stated how important a good meter reading and billing system is; how unaccounted for water must be monitored; how important system limitations are; and how consumption must be designated into user patterns.

The engineering functions cannot be carried out properly unless there is adequate finance to provide the required service.

No scheme can go ahead without a financial package and the finance will depend upon the other ancillary functions being correctly administered.

Revenue is primarily collected to balance the budget, but it can also be used to control demand where a variable tariff structure has been introduced.

The engineering and financial functions are interlocked and expenditure can be made only if there are adequate funds to finance the requirements.

7. CONCLUSIONS

7.1 INDEPENDENT ASSESSMENT

No organisation can function efficiently, or properly plan for the future, without the correct information.

Major water schemes are expensive and existing facilities must be properly utilised. To allow a large proportion of the product to be unaccounted for is not acceptable - not to know that proportion is even worse.

It is therefore essential to obtain an unbiased factual opinion of the state of any organisation.

The data provided will vary with time and therefore it must be continuously updated to cater for all variables.

The audited accounts provide some information, but do not cover the detail that has been highlighted in this paper.

Often people do not have the time or resources to look into individual problems - yet a full investigation can provide enormous benefits.

An organisation with operational expertise can not only provide the personnel but also assist in implementing and monitoring improvements. Consideration should be given to conduct the water audit to the required degree of detail at set time intervals.

7.2 ALTERNATIVES AND COSTS

There are often numerous alternative approaches to providing adequate water - some involve major capital expenditure, others involve minor improvements. Most depend on the ability of the water undertaker to generate enough income to service the debt and pay everyday running expenses.

Alternative schemes will forecast the capital and running costs of providing a cubic metre of water or treating the sewage. Obviously, the allowance incorporated in the forecasts for unaccounted for water will have a considerable effect on the anticipated long term costs to consumers.

It is therefore essential not only to know the basic data but also to demonstrate the origin and accuracy of it, and where improvements are to be made then the results should be monitored.

7.3 BENEFITS

It is hoped that this paper has explained the importance of a water audit. No figures have been used since every situation is different. However, most people can see the possible benefits around them; if they cannot, then possibly there is a shortage of reliable data.

It is important for management to identify what they hope to obtain from a water audit to establish the appropriate depth of investigation. The improvements can be made only with the full co-operation of the employees. Obviously a continuous training programme is essential irrespective of an audit and this has not been dealt with in this paper.

The end result should be to establish a system where the monitoring of the data allows control.

PAPER 3

ORGANISING MAINTENANCE IN WATER SUPPLY PROJECT IMPLEMENTATION

BY

EBBO HOFKES

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SUMMARY

Maintenance is the key to a water supply system's success or failure. Organising proper maintenance can, and should, be viewed as an investment project; and a sound investment indeed!

Although maintenance basically is, and always will remain, the recipient country's own responsibility, external financial and technical assistance can be instrumental in establishing a maintenance system, especially in the initial stages. At present, most governments of developing countries have only very limited budgets for meeting the maintenance costs of water supply installations. Resources required for maintenance are frequently underestimated in rural water supply project proposals, and it is not unusual that the budget authorities make further reductions when it comes to allocations.

The financial burden on developing countries' governments from the maintenance costs of water supply installations is rapidly increasing in those countries where water supply has been, and continues to be, undertaken as a social service. It appears that at least the direct costs of maintenance must be born by the beneficiaries, or water supplies will be going out of service at the same rate as they are being installed.

Operation and maintenance are the business end of all water supply systems. Provision of adequate maintenance is a complex matter, due to the interdependent nature of the activities involved. There always is a strong tendency to lose direction in vicious circles of breakdown and failure. However, if rural water supply programmes are to have continued impact, the problems of maintenance must be tackled with improved strategy, adequate financial and technical means and the necessary skilled manpower.

1. INTRODUCTION

Maintenance is one of the most neglected aspects of water supply projects. The number of inoperative water supply installations remains discouragingly high. Experience shows that it is usually more difficult to keep water supply systems running than to construct or install them. If no ways can be found to provide for the maintenance of existing installations, it would probably be better to postpone new projects. Instead, attention would have to be focussed on the rehabilitation of existing water supply installations.

International organisations and bilateral aid agencies offer funds for new construction but are not so readily prepared to finance maintenance costs, considering this to be the responsibility of the recipient country. For their part, the countries receiving assistance have a legitimate need for additional water supplies but at the same time find it difficult to make adequate provision for the maintenance of the existing ones. It happens, therefore, that new water supply systems are sometimes installed to replace existing ones which could have been rehabilitated at much lower cost.

Although maintenance basically is, and always will remain, the recipient country's own responsibility, external financial and technical assistance can be instrumental in establishing a maintenance system, especially in the initial stages. At present, most governments of developing countries have only very limited budgets for meeting the maintenance costs of water supply systems. Resources required for maintenance are frequently underestimated in rural water supply project proposals and it is not unusual that the budget authorities make further reductions when it comes to actual allocations.

Maintenance is the key to a water supply system's success or failure. Organising proper maintenance can, and should, be viewed as an investment project; and a sound investment indeed!

2. PROBLEMS OF MAINTENANCE

2.1 GENERAL

Maintenance has to do with keeping and nursing what is already there and sustaining it so that it will provide the required service. It is the art of keeping equipment, installations and other facilities operating to perform the services for which they are intended. Proper maintenance is needed for water supply installations as for other engineering systems.

The point that will be stressed throughout this paper simply is that the trend of serious operational problems and failures of water supply installations will continue unless the lessons of the past are learned and utilized.

2.2 CURRENT SITUATION

It is common that, two to three years after construction, 50% or more of rural water supply installations in developing countries are no longer functioning either because of mechanical failures or due of neglect of maintenance. When spare parts are not available, when a water treatment plant operator or pump attendant has to go without any assistance or compensation for months on end, when the water supply is unreliable and irregular, people lose heart and return to their traditional, polluted sources.

In practice, preventive maintenance of water supply systems is very rare and the organisations that are responsible for maintenance merely send out repair teams when a breakdown occurs. This is regrettable because considerable economic savings can be achieved when preventive maintenance is provided instead of repair after breakdown.

For example, a country may have some 20,000 rural water supply systems, representing an average investment of US $ 25,000 each. If only 60% of the systems are functioning, then 8,000 systems are out of operation at any given time. Should an improved maintenance system result in the proper and continuous functioning of 4,000 out of these 8,000 systems this would be equivalent to recovering a capital investment of US $ 100 million.

2.3 ORGANISATIONAL DEFICIENCIES

One reason why maintenance of many rural water supply systems is not provided for, is that the organisation which is responsible - or is made responsible - for maintenance frequently is another one than the organization that constructs or installs the facilities. Too often, without any real justification it is assumed that the local community will somehow maintain its new water supply installation.

The construction and installation activity will generally be separate from the maintenance programme. Construction work has its own set of objectives and priorities. These are seldom in keeping with the timing and organisation of maintenance. Obviously, the maintenance organisation should coordinate its programme with the construction activity so that the maintenance programme can be started immediately when construction work is completed.

Water supply organisations frequently tend to restrict their planning to the construction and installation activity only, to the exclusion of other aspects. In particular, adequate staffing and budgeting for maintenance, and the provision of spare parts are neglected. As a result, resources are often unavailable for maintenance. Poor planning then becomes evident when the maintenance system fails.

2.4 FINANCIAL CONSTRAINTS

The financial burden on developing countries' governments from the maintenance costs of water supply systems is rapidly increasing in those countries where water supply has been, and continues to be undertaken as a social service. It appears that at least the direct costs of maintenance must be born by the benificiaries, or water supplies will be going out of service at the same rate as they are being installed.

A national water supply programme requires a long term commitment to proper maintenance. Regardless of whether the funds come from national or external sources, the relationship between new installation and maintenance exists and should be considered from the start. Neglecting the need for maintenance implies risking all the investments made in a rural water supply programme.

But most governments of developing countries at present have only very limited budgets for meeting the maintenance costs of water supply installations. Resources required for maintenance are frequently underestimated in proposals for rural water supply projects and it is not unusual that budget authorities make further reductions when it comes to actual allocations.

The cost of maintaining water supply systems can be quite substantial and there are situations (for example, dispersed location and long distances) where any attempt at centrally-organised maintenance, however modest, would incur prohibitive costs. The key point for the government or the national water supply agency is to avoid an accumulation of maintenance costs which cannot be financed within the regular budget. The degree of centralization in the maintenance system has a great influence on the costs that are to be met from government funds.

2.5 IMPACT OF POOR DESIGN AND EQUIPMENT

The effectiveness of any maintenance system for water supply installations can be marred by the use of poor designs or the installation of equipment of poor quality. Poor designs or equipment with inherent manufacturing defects will not be economical to maintain and any savings in the initial construction or installation costs are likely to be more than offset by heavy maintenance costs.

In view of the urgency of providing safe drinking water, rural water supply programmes sometimes make the mistake of relaxing quality standards in construction and installation work. Poor designs and poor-quality equipment are allowed to be used. This will first strain and, then, break the maintenance system.

3. KEY CONSIDERATIONS

3.1 BASIC APPROACH

One approach to maintenance of water supply systems is that the problem is not so much that a water supply installation breaks down but that there should be somebody on the spot who has the skill and means to repair it. Many experts, especially those with extensive field experience, feel this may be rather over-simplifying the question. It is obvious that too frequent breakdowns will greatly impair any newly-established habit of using water from the new water supply system rather than from the traditional polluted sources. Even if the water users have developed an awareness of the relationship between health and water, they are not going to accept too many wasted journeys finding a broken-down handpump or a standpipe that does not give water.

Once a water supply installation is provided, it is important to ensure that the community continues to rely on it. Thus, it is essential that the installation should be kept operating. If it breaks down and remains inoperative for long periods of time, people will return to their traditional water sources and the opportunities for improving the attitude towards a safe water supply will be lost probably for years. Furthermore, where the water supply was installed with contributions from the local community they may view its failure as evidence that their contribution has been wasted.

The key argument in this paper is that for a rural water supply programme to be effective clear choices need be made as to which maintenance tasks are to be undertaken by the local community and which will be the responsibility of the government water supply agency. That is, the choice of zero maintenance is not a real option! The zero maintenance concept is often used as a claim to justify a high-priced technology. While it is true that well-designed, heavy-duty installations require less repair they really always need maintenance.

3.2 COMMUNITY INVOLVEMENT IN MAINTENANCE

Increasingly, we see that the local community through a resident working on a voluntary basis or paid by the government is required to assume responsibility for the basic village-level maintenance duties and the immediate reporting of breakdowns. Routine maintenance includes such work as lubrication, bolt tightening and minor repairs. But, the caretaker or plant operator will need support from a mobile maintenance team operating from the district centre to carry out the major maintenance task and the regular servicing of the water supply installation. Maintenance purely dependent on voluntary work on a continuous basis, is asking too much of a small rural community.

As, with a proper involvement of the community, the functioning of a maintenance system, more and more, will depend on both the local community and the governmental maintenance organisation, it will be absolutely essential that it is clear which maintenance tasks are assigned to the local community and which will be provided by the central maintenance organization. The responsibilities of each must be allocated with a considerable degree of detail.

A water supply programme without a parallel maintenance system is incomplete. Maintenance is a tangible requirement, and the question should not be whether or not to have maintenance but how it should be organised.

4. ORGANIZATION OF MAINTENANCE SYSTEMS

4.1 GENERAL

To organise a maintenance system for rural water supply installations is not an easy task. It calls for setting up an organisation with the necessary personnel, equipment and materials. The following questions need to be considered, when organising a maintenance system:

- Where is the work to be done? On site? In a workshop?
- Who should do the work? The level of technical expertise and the number of needed personnel.
- When should it be done?

In selecting a maintenance system, factors such as distance and accessibility of the water supply systems and the required frequency of routine servicing and repair are essential considerations.

Another important factor is the rate of expansion of the national water supply programme. There is always a danger of trying to expand too quickly while neglecting maintenance. It takes years to train staff, to arrange for procurement of plant machinery, and to establish a spare parts distribution network. Most difficult of all is the task to train people for their role in the maintenance system. Working continuously and starting for a zero-base it usually takes at least four to six years before a maintenance system is established and reasonably effective, even in a country that is otherwise ready to absorb an expanding rural water supply programme.

4.2 DIVISION OF MAINTENANCE ORGANISATION OVER DIFFERENT LEVELS

There are no fixed rules to determine which mixture of centrally-organized, district-type, or community-level maintenance, is the right choice for a particular country or region. The point that must be stressed is simply that one should be clear from the outset about the kind of maintenance system which is to be developed in a water supply programme. To plan a system totally or partly based on centrally-organised maintenance, only to find that it is not provided or on a patchy basis, is to invite failure.

In practice, the extremes of either complete government service or all responsibility exclusively with the communities are the exception. Usually, it is a shared responsibility.

Most maintenance systems can be characterized as one-tier, two-tier or three-tier structures. A one-tier system exists where all maintenance tasks are the responsibility of a central organization, or where they are undertaken exclusively by the rural communities. In the two-tier system the maintenance operations are shared between the central agency and the communities. In the three-tier system the intermediate level of government (that is, the district) assumes a specific part of the maintenance duties.

4.3 TYPES OF MAINTENANCE SYSTEMS

(a) CENTRALLY-ORGANISED MAINTENANCE

Where the government assumes all responsibility for maintenance it has to provide staff, training, equipment and transportation. It will have to establish workshops and stores, and will have to arrange for the distribution of spare parts. It has to extend its maintenance system down to the village-level with a villager employed as caretaker or plant operator for each water supply installation.

One advantage of the government taking all responsibility for maintenance would be that there will be no doubt where the responsibility rests. Especially, where one government organization would handle installation as well as maintenance, proper construction and installation can produce a direct benefit in terms of reduced maintenance costs.

Figure 1 shows a typical organization chart of a centrally-organised maintenance systems.

Experience has shown that although centrally-organised maintenance systems can be effective in the initial stages of a rural water supply programme, they usually do not keep up with the requirements when the programme expands. Often, after some time they become understaffed, undermotivated, and incapable of meeting the maintenance workload. Gradually or rapidly, the planning tends to become unrealistic and inadequate, the financial and manpower resources insufficient, and the maintenance structure will begin to disintegrate.

What will happen in practice with a small water supply system such as a handpump or a small pumping station that the distant central government agency would probably regard as too small an item to send a mechanic over a long distance just for routine maintenance. The pump will be used by the people for as long as it works, but in the end the inevitable will happen and the pump will break down. The villagers will open the cover of the well, or will draw water directly from the open source. this negates the very purpose for which the pump was installed: the provision of a safe water supply.

(b) COMMUNITY-LEVEL MAINTENANCE ORGANISATION

The present state of water supply technology and community capabilities usually do not make it possible to implement a community-level maintenance system from the start. However, in terms of viability and costs, it is simply mandatory that maintenance programmes should eventually develop towards such a system. To allow this, the designs of pump and plant machinery will need to be adapted, and more intensive and specific training of the local caretakers is necessary. To make such a system viable in practice, it is essential that community involvement is stimulated and capabilities are developed so that community-level maintenance will become realistically possible, step-by-step.

For even a minimal degree of community involvement in the maintenance of water supply installations, the attitude and interest of communities is a decisive factor. Where the water supply system is provided without adequate introduction and communication, the new water supply will be seen as something provided by the government without request or consultation. Usually, under such conditions the community will take no active part and will expect the government to maintain its water supply installation. Awareness of the importance of safe drinking water should not be expected to exist at the village level. Rural populations often are unaware of the relationship between their traditional, polluted water sources and the incidence of water-related disease. Thus, there is a real need for health education which should aim at developing awareness of the importance of safe water.

One great advantage of a determined policy of encouraging village-level maintenance of water supply systems is that it can bring out local intitiative. It can also help reduce the burden of maintenance costs on the government.

It should be recognized that presently a village-level maintenance system based entirely on local resources and with little or no government-organised backup service is very likely to fail in the early stage. It is not reasonable to expect small communities to maintain their water supply installation immediately and fully. When people are not yet accustomed to using the water supply and not yet appreciate the benefits of it, the first breakdown of the installation may provide a convenient excuse for them to return to their traditional, polluted water sources.

In the initial stages, mechanics of the government water supply agency should be providing technical assistance in the maintenance of new water supply installations. Their job would be to check the technical condition of the installations, to assist in routine maintenance, to carry out minor repairs and to call in the district maintenance team for the major repairs. This technical support in the initial years leading up to the eventual village-level maintenance system, is an essential element in developing a maintenance organisation.

The overall costs of a village-level maintenance system for water supply installations will probably be not less than under other systems. But the burden of costs to be met from government resources will be substantially reduced.

5. MAINTENANCE SYSTEM NEEDS

5.1 MAINTENANCE MANUALS

One of the most basic requirements of a maintenance programme is a complete set of the manufacturers' installation and maintenance manuals for all the plant and equipment used. These manuals are important, and should be filed in an orderly manner in a secure location. Using the manuals as a basis, an inventory of the maintenance tasks to be performed on each piece of equipment can be made, with the frequency of required maintenance listed as well.

5.2 MAINTENANCE RECORDS

The need for proper record keeping as a basis for scheduling of maintenance cannot be over-emphasized. Only from such records, is it possible to determine the required frequency of servicing the installations, the time the maintenance jobs take, the actual performance and reliability of the various plant and equipment, and which spare parts should be stocked in what quantities.

Maintenance records are mostly kept on cards, one for each piece of equipment. On these cards should be kept a record of regular lubrication, inspection, cleaning, replacement of worn parts and other data of importance. The data for the next regular servicing of the equipment should be noted.

Examples of maintenance record cards are shown in Figure 2.

All costs to maintain a particular piece of equipment over time are recorded on the card. This record makes it possible to determine whether the unit is more or less expensive to operate when compared with another unit from the same or different manufacturer. Over an extended time period, it provides a basis to predict, for instance, when a seal will fail, when switchgear will burn out, or when some other event requiring maintenance attention happens.

5.3 METHODOLOGY

In the design of a maintenance system, the failure-mode distribution, in principle, should be used as the basis. However, detailed actual data on the nature and frequency of breakdown of equipment, and their components in particular, is rarely available. What information there is, is mostly sketchy, qualitative and in some cases apparently even incorrect.

The basic approach, however, should be to first determine the failure-mode distribution, and then to detail the maintenance tasks in terms of nature and frequency needed.

The modes of failure are determined either by direct observation, in the case of visible defects, or by inference when it concerns internal components of equipment, or below-ground parts of pumps on wells. On-site determination of the mode of failure involves heavy expenditure of time and money in travelling. Review of maintenance and repair records is more efficient, if such records are kept in an acceptable way. The mode of failure can then inferred from them, and a failure mode frequency distribution can be made. Figure 3 gives an example concerning handpumps.

The proportion of water supply systems (for example, handpumps) working at any given time depends on the frequency of breakdown and the speed with which breakdowns are repaired.

With:
- N_o = total number of pumps at time t=0 (all assumed to be working),
- i = rate at which new pumps are installed,
- r = rate at which broken down pumps are repaired,
- N = total number of pumps existing at any time t,
- p = total number of pumps in working order at time t,

and
- m = mean time between failures of a pump.

the following equation applies:

$$dp/dt = r + i - p/m \qquad (1)$$

The initial condition (t=o) is $p = N_o$

When a handpump installation programme has been under implementation for several years, and provided an effective maintenance organisation has been established, it may be assumed that broken down handpumps are being repaired at a constant rate: r = constant.

The number of pumps installed (the pump population) can be written as:

$$N = N_o + i.t \qquad (2)$$

At the completion of the handpump installation programme, i becomes zero.

Working out the differential equation (1), gives:

$$p/N = (1 - mr/N)\exp(-t/m) + mr/N \qquad (3)$$

This equation shows that after completion of the pump installation activity, the proportion of working pumps falls exponentially to an asymptotic level of mr/N.

It is now possible to estimate the important parameter m (which is the mean time between failures, MTBF), as a basis for designing the maintenance system.

For example, with a pump population of 24,000 and an MTBF = 20 weeks, the maintenance capacity to keep all the pump working should be 1,200 pumps per week, assuming that no new pumps are installed.

If there is no maintenance organization, then r = o, and equation (3) becomes:

$$p/n = \exp(-t/m)$$

It shows that the proportion of working pumps will decrease exponentially.

5.4 MANPOWER

A variety of skills is needed for running a maintenance organisation. In the final analysis it is the maintenance personnel which will make or break the maintenance system, and determine its efficiency. The following manpower needs are to be provided for:

- management, supervision;
- training;
- routine maintenance (preventive);
- repairs and overhauling of pumps;
- spare part supplies;
- vehicle maintenance.

The number of staff to be employed by a governmental maintenance organisation will be greatly influenced by the degree to which the local communities share in the maintenance activities.

No definite data on manpower needs can be given. Perhaps the numbers of staff employed in handpump maintenance systems in Tanzania, Bangladesh and India, as shown in Table 1, may provide an indication.

Table 1. Numbers of staff in handpump maintenance systems

Personnel per 10,000 handpumps

	Tanzania		Bangladesh	India
	(a)	(b)		
Executive level and above	30	5	1	1
Middle level	60	10	9	18
Lower level	130	75	50	160
	180	90	60	180

(a) Centralised maintenance system

(b) Decentralised maintenance system, with village communities taking responsibility for simple, daily maintenance tasks and minor repairs.

Clerical and administrative posts required in the maintenance organization are not shown. In addition, other units of government may have to be strengthened in order to cope with the management and administration of the maintenance programme.

It has to be said, that in many developing countries existing maintenance organisations have acquired a workload out of all proportion to their staff resources available. The maintenance workload is further aggravated by faults in the planning and design of the water supply systems. Situations in which the maintenance staff are required to maintain incomplete or poorly constructed water supply systems are unfortunately not unusual.

A sketch plan of a maintenance training centre is shown in Figure 4.

5.5. TRANSPORT FACILITIES

The number and types of vehicles required by a maintenance organization will largely depend on the topography of the country and its transport infrastructure such as roads and railways. In many countries, transport by road will be the most common. Senior staff of the maintenance organization would require vans or cars, possibly with four-wheel drive. For the transport of the necessary equipment and maintenance materials, pickups or trucks will be required. However, motorcycles and bicycles should have preference to cars. All transport units themselves require maintenance, and the maintenance organization will have to make provision for the upkeep of its vehicle fleet, and a supply of the spare parts needed. The cost of maintaining the vehicle fleet and the depreciation of the vehicles quite often form a substantial part of the overall maintenance costs of water supply schemes.

The vehicle maintenance itself often experiences serious problems. Because of shortages of spares, vehicles are frequently off the road for long periods awaiting spare parts which are in short supply.

5.6 MATERIALS AND EQUIPMENT

The maintenance organization will require materials and equipment for routine maintenance tasks, and for making repairs. The equipment needed includes wrenches, lifting gear, screwdrivers, hammers, hack saws and whatever other tools and equipment are needed. The local caretakers/pump attendants should be provided with a set of tools to carry out the basic maintenance duties, such as bolt tightening and the replacement of worn parts in the top-end of the pumps.

5.7 HOUSING

In a government-organised maintenance system, staff frequently claim living accommodation and, dependent on local custom, it may be necessary to construct housing for these people. This is mentioned here because, in estimating the capital investment for a government maintenance system it may be necessary to allow for the construction of staff housing. For the lowest level of staff who will be in the largest numbers, housing would probably not be considered the government's duty. However, if they are expected to carry out their tasks conscientiously, they must either be given a sufficient allowance to rent their own accommodation, or they must be provided with living quarters. In several countries, the provision of staff quarters has been found the most appropriate arrangement.

5.8 OFFICES, STORES AND WORKSHOPS

An essential part of any maintenance organization is a network of offices, stores and workshops. At these locations the government personnel will have their bases. Maintenance materials will also be stored here. Generally, these workshops and offices will be located at places that fit into the organizational structure of the government. The planning of a spare parts distribution system will have to take into account where the sources of supply are. In places where spare parts are issued, it is often economical to collect the replaced items. These can be sold as scrap or perhaps it is possible to recondition them.

6. <u>FINANCING OF MAINTENANCE SYSTEMS</u>

6.1 <u>FINANCIAL ARRANGEMENTS</u>

An important factor for the viability of any maintenance structure for water supply systems, is how the maintenance costs are met.

Water supply installations, whether large or small, require funds for their maintenance. This is true whether water is distributed through private connections, or through standpipes scattered throughout the village or town. People served by piped supplies often believe that the only investment made to bring them water was the pipe laid in front of their homes and the cost of their meters and service connections. This is far from the truth and the customers should be brought to understand that the cost of these items represents only a small fraction of the total cost of supply, storage, pumping, treatment and distribution.

It is firmly believed that no matter how poor a community may be, some water charges can and should be collected from the consumers. It has been said that the day people start receiving water free of charge, marks the beginning of the downfall of the water supply system. No favours should be granted and no exceptions should be made in the collection of water fees. This is the best way of guaranteeing revenues for a satisfactory service. Agreement on this issue should be reached with the local community before, not after, construction of the water supply system has started.

Basically, revenues should provide sufficient funds to pay for all operating and maintenance expenses, and as far as possible, also the fixed charges relating to depreciation and interest on long-term debt. In many instances, however, rural communities rely on subsidies from the provincial or central government to finance and maintain the water supply system.

The way costs of maintenance services and spare parts are financed, greatly influences the distribution of the costs over the various sources of finance. The following options exist:

(1) <u>Government pays</u>:

Where the government pays all costs of maintenance and spare parts, the maintenance organization must extend down to the village level. It is quite possible for a villager to be employed by the government as the caretaker/pump attendant for each water supply system installed, but this will further add to the financial burden on the government.

(2) <u>Government subsidises</u>:

Under this method, the government will be financing the fixed costs of the maintenance organization, and the local communities will have to pay the cost of the spare parts, and perhaps also a service charge for the actual maintenance work on their water supply system. Or the communities may organise themselves to carry out the simple maintenance tasks and minor repairs, with the government carrying out and financing the major maintenance and repairs. The government organization, in this system, has to collect service charges and payment for spare parts, and should recycle these funds for the purchase of new supplies of spare parts. The handling of, and accounting for such funds may present a major administrative problem. It may not even be possible directly to recycle revenue to meet the costs of spare parts supplies, in cases where regulations prescribe that revenue must be paid into the general government account.

(3) The community pays all costs:

In this case the people may either pay the full charge for the maintenance service provided by the government organization, or all costs of hiring local technicians to carry out maintenance and repair tasks. With this financing method the maintenance of the water supply system becomes completely the responsibility of the community.

Revolving funds appear to offer one of the best possibilities to establish long range financing, especially for rural water supply programmes. It involves the establishment of a fund at the provincial or national level to finance water supply projects. Loans are made from the revolving fund, and as repayments come in from the communities served, these can be used to finance further projects (Figure 5).

6.2 CHARGING FOR WATER

For piped water supplies, metering of individual connections and standpipes can be used as a basis for charging the water users, but the actual revenue collection is often difficult. When water is supplied from public standpipes, cash payment on the spot should be collected, or a flat rate should be paid through family fees, head taxes, a water tax, or an assessment on property.

For handpump water supplies, metering is not realistically possible. Cash collections for maintenance have proved very difficult to organize, although much smaller sums are involved than the initial contribution for construction whether in cash or in kind. Villagers often feel that the initial payment which usually is a substantial sum out of a meagre household budget, is their total and final payment for the water supply and they resent calls for further payments. The result is that, when a breakdown occurs and repair is needed, a series of meetings may be held during which the committee attempts to work out the amount of cash needed to repair the supply. Where contributions to the repair costs are not forthcoming, the committee will have to attempt to impose sanctions on non-contributors.

However, there are examples of situations in which the collection of water charges for maintenance and repair, has been relatively successful.

In a recent survey of two villages in Upper Volta, the feasibility of a financial contribution from the villagers in the costs of maintaining a new handpump water supply were investigated. The study method used was to relate the actual expenses for the ropes and buckets used to lift water from existing open wells, to the estimated costs of maintaining a handpump (Table 2).

TABLE 2

Expenses for ropes and buckets in two villages in Upper Volta.

number of persons per family	village of BOARE population: 1130		village of ZIZIN population: 369	
	expenditure per person	% of estimated total expenses	expenditure per person	% of estimated total expenses
less than 6	342 CFA	9.5%	162 CFA	2.9%
between 6 and 10	185 CCFA	5.2%	164 CFA	3.0%
more than 10	140 CFA	3.9%	145 CFA	2.6%
average family	192 CFA	5.4%	155 CFA	2.8%

* the higher costs in Boare village are due to the greater depth of the well
** the village of Zizin is more wealthy
100 CFA= US$ 0.40

As the water supply situation in the village of Boare was very inadequate, the people were found willing to pay an extra charge of 60 CFA per person. Moreover, they would be prepared to assist in the installation work needed to improve their water supply. Apparently, it is possible to obtain some contribution from the users for meeting maintenance costs, provided the new water supply is regarded by the people as much better than their existing one, and does not cost more than their current expenses for water.

A World Bank study has shown that people usually are not prepared and, in fact, often unable to spend more than 3 to 5% of their cash income on water.

Of interest is another option for the financing of handpump maintenance costs, which was also considered in Upper Volta. According to this plan, the costs of handpump maintenance would be financed by a surtax on beer and alcohol. In Upper Volta, and perhaps in many other countries, these are regarded as a luxury.

6.3 MAINTENANCE COSTS

In many countries, inadequate financial resources are the main reason behind the malfunctioning and breakdown of water supplies.

There is frequently a widening gap between actual expenditure on maintenance of rural water supplies and the needed budget. In one country, the current budget allocation for operation and maintenance of water supply systems is only 2% of the cumulative capital investment at 1976 prices, so that the actual allocation at current prices amounted to as little as 1.4%. Sample calculations based on actual costs of maintaining water supply systems, indicate that the percentages of capital investment required for efficient operation and maintenance, are much higher (Table 3).

TABLE 3

Maintenance costs, expressed as per percentage of capital investment

- Large gravity supply systems	3.7%
- Large pumped schemes	6.3%
- Small pumped water supply systems	6.0%

These estimates do not include overheads, and are indicative only. For accurate estimates of operation and maintenance costs, actual cost data should be used as a basis for calculations.

Actual maintenance costs, obviously, are very much dependant on the number of water supply installations and the distances they are apart; the prices of fuel, spare parts; and the durability of the equipment and machinery. Actual cost data for operation and maintenance of water supply systems are hard to come by.

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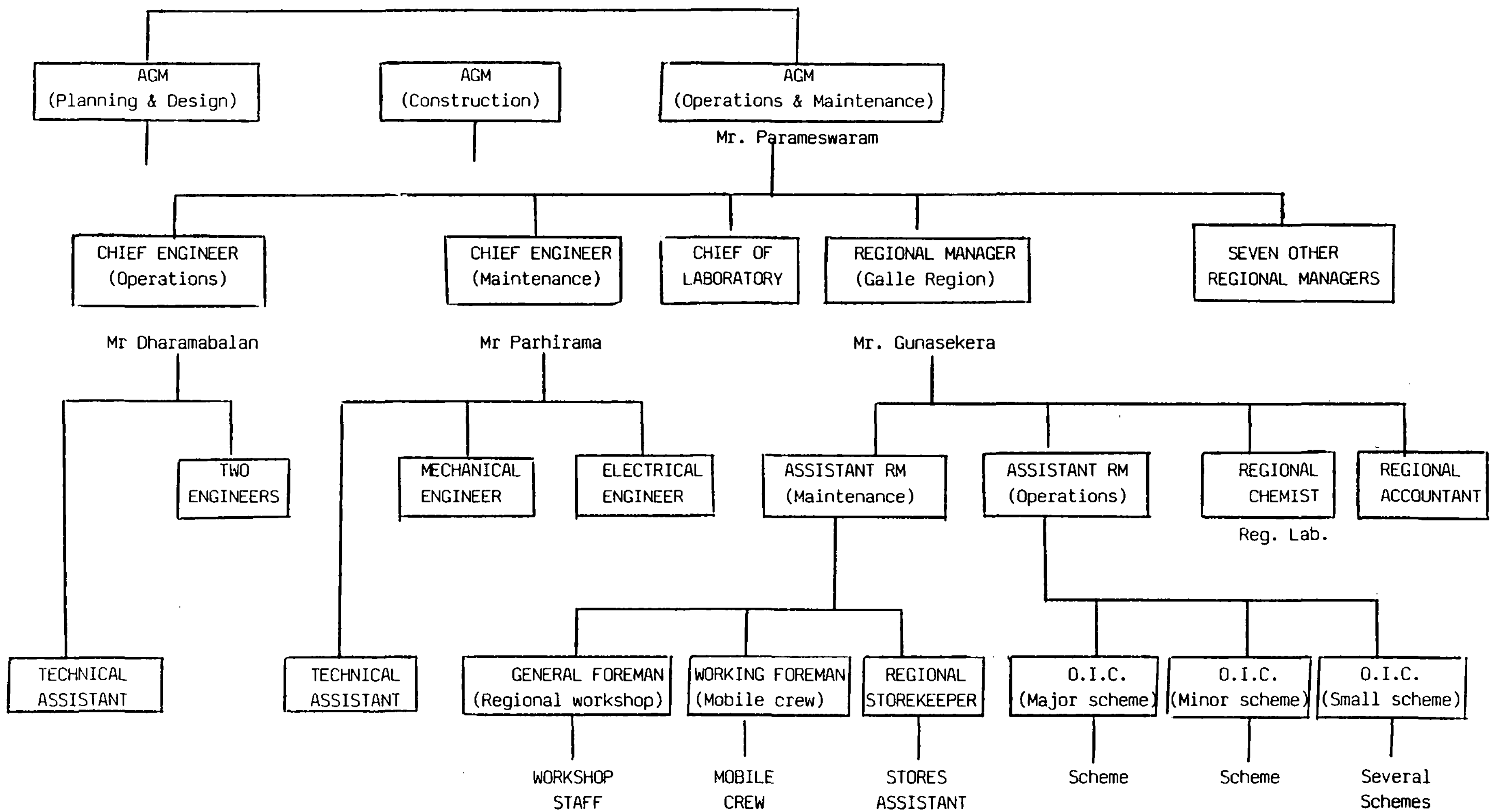


FIGURE 1 Organisation chart of centrally-organised maintenance system (Sri-Lanka)

DISTRICT MONTHLY REPORT

District .... Month ending .... 19..

1. From Motorcycle Inspection Log

a. No. of hand pumps inspected ....
b. No. working on arrival ....
c. No. working but repaired by motorist ....
d. No. not working and repaired by motorist ....
e. No. working but requiring service truck ....
f. No not working and requiring service truck ....

2. a. No of hand pumps reported not working by villagers but not reported by motorist ....
   b. No. of hand pumps reported not working by villagers and also reported by motorist ....

3. a. No. of hand pumps serviced ....
   b. No of pumps requiring service at month end ....
   c. No of mechanical pumps serviced ....

4. Hand Pump Inventory

	TYPES OF PUMPS			
a. Hand pumps on wells in District at end of last month	....	....	....	....
b. Hand pumps removed from old wells	....	....	....	....
c. Hand pumps installed on old wells	....	....	....	....
d. Hand pumps installed on new wells	....	....	....	....
e. Total hand pumps on wells in District at end of month	....	....	....	....
f. Hand pumps in stock requiring repairs	....	....	....	....
g. Hand pumps in stock ready for installation	....	....	....	....

5. Vehicle usage

	miles travelled	gallons of fuel	m.p.g.
a. Motor Cycle No	....	....	......
b. Motor Cycle No	....	....	......
c. Service Truck No.	....	....	......
d. Service Truck No.	....	....	......

SERVICE TRUCK REPORT

Date ....

District .... Service Unit ....

Travelling time .... Time spent on site ....

Well number .... Village ....

Type of pump .... Static water level taken Yes No (from top of concrete base)

Pump operating on arrival Yes ... No ...

Work done	Parts replaced	
	Number	Name
....	......	....
....	......	....

Comments: ....

3 Copies

1. White to Region Officer
2. Canary to District Office
3. Pink remains in Report Book

.... Serviceman's signature

.... Serviceman's name

VEHICLE DOWN TIME

NOTE: RECORD ONLY WORKING DAYS VEHICLE WAS NOT USED

District .... Month ending ....

Vehicle No .... No of working days ....

No of days worked ....

Date	No work to do	No Operator	No petrol	Mech problem	weather	other
....	....	....	....	....	....	......
....	....	....	....	....	....	......

WELL SERVICE RECORD

Well No ....

District .... Village ....

Well Location ....

Type of pump ....

Date well drilled .... Depth of well ....

Diameter of casing .... Recommended yield ...... Igpm

Date serviced	Pump operating on arrival		Work done	Parts replaced		Static water level
	Yes	No		Number	Name	

RECORD OF BROKEN-DOWN HAND PUMPS

District ...., Month ending ....

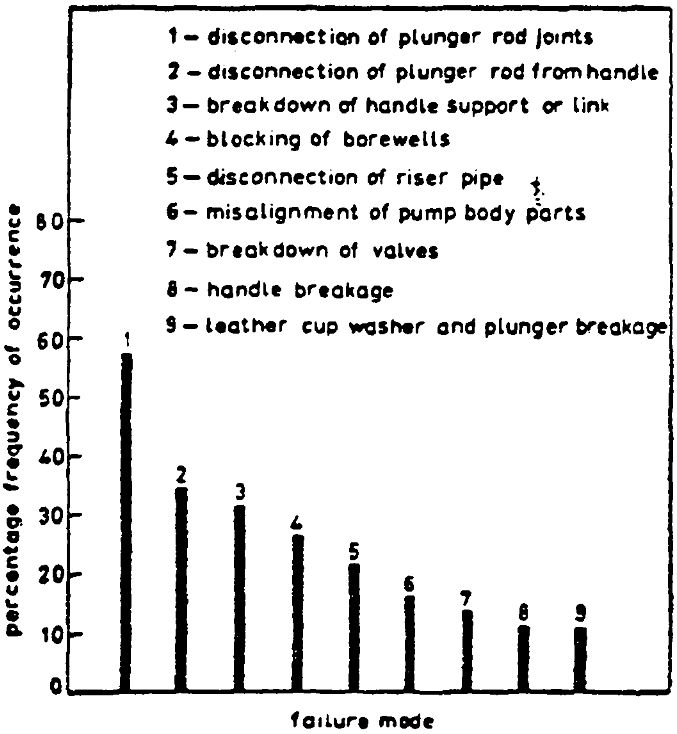
Well No	Type	AG	BG	Date down	Date repaired	Remarks
....	....	....	....	....	....	....
....	....	....	....	....	....	....

RURAL WELL INSPECTION LOG

Well No.	Date	Village	Odometer reading	Well operating on arrival		Work done	Parts replaced	Service Truck required	
				Yes	No			Yes	No
....	....	....	....	......	......	....	....	....	....
....	....	....	....	......	......	....	....	....	....

Source: Upper Region Water Supply Project, Ghana

FIGURE 2 MAINTENANCE RECORDS



Source:
Rama Prasad. Handpumps: problems and the search for remedies. Proc. Indian Acad. Sci. Vol C2, Dec. 1979.

FIGURE 3 EXAMPLE OF FAILURE-MODE DISTRIBUTION

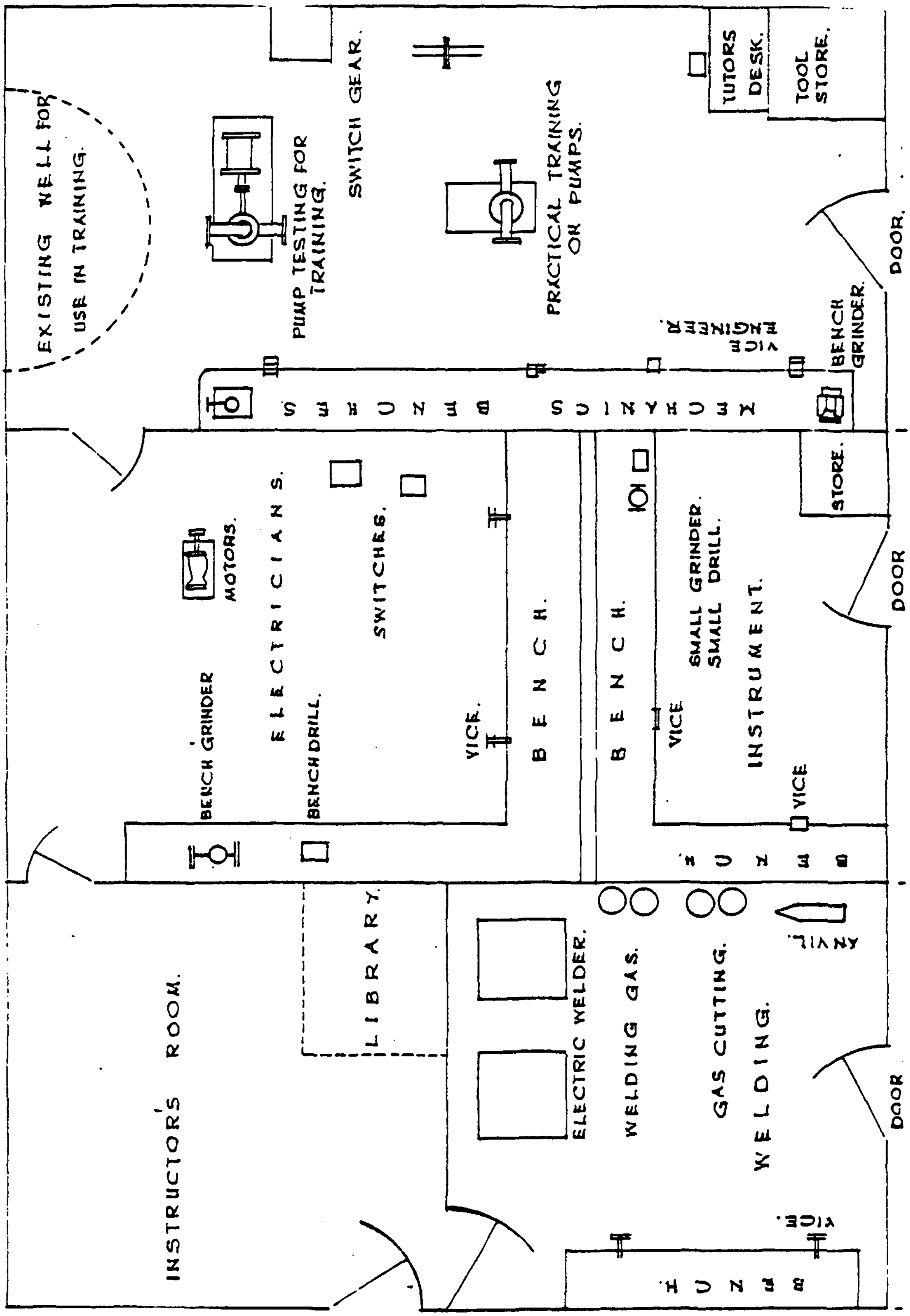


Fig.4. Sketch plan of Maintenance Training Centre.

Source: Maintenance Organization Study (Sri Lanka)
IRC Manpower Development Programme

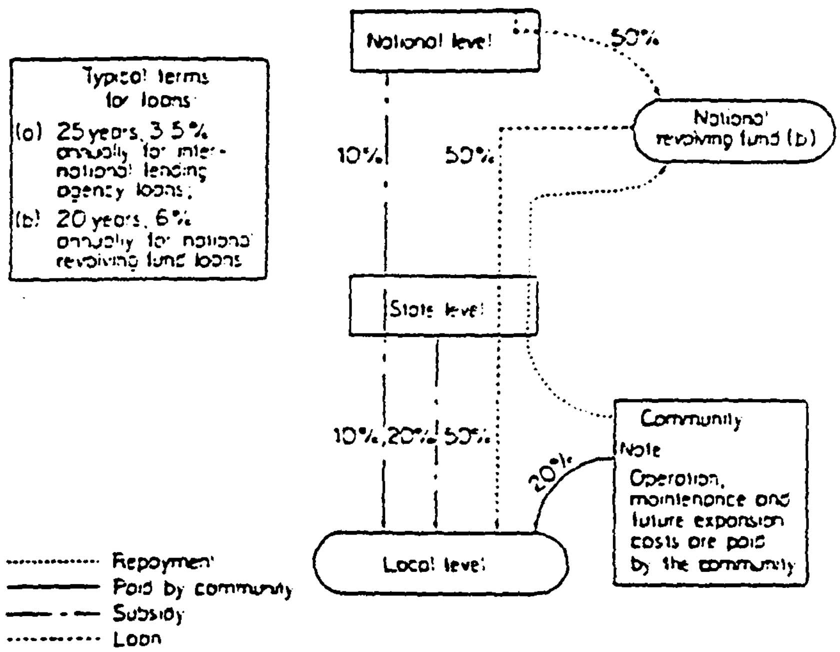


Fig.5 A revolving fund arrangement

PAPER 4

IMPLEMENTATION OF RURAL WATER SUPPLY PROJECT IN CENTRAL REGION, ETHIOPIA

BY

P.H.W. BRAY, BSc (Eng), FICE, P. Eng (BC)
ASSOCIATE, SIR M. MACDONALD AND PARTNERS, U.K.

SUMMARY

The paper reviews the implementation of rural water supplies in Ethiopia from the setting up of the regional office through construction, operation and maintenance between mid-1976 and early 1980.

Central Region had an estimated rural population of five million (about 20 per cent of Ethiopia's total rural population) and, with a density of 50 per km^2, is the most densely populated region.

The British funded six man expatriate team first had to prepare an inventory of existing systems and resources and recommend rehabilitation and new works. Subsequently the team set up the regional office with an ultimate staffing of over 200, and instituted stores and office procedures. Following the preparation of selection and design criteria, the new schemes were designed, built, and staffed. Their operation was supervised and maintenance carried out.

Careful cost accounting procedures were adopted so that the costs of each scheme could be analysed. In all some 30 schemes were investigated and designs prepared with borehole, hand-dug wells, and spring capping being used as sources. By March 1980 water was provided through 23 completed schemes to an estimated total population of 107,500 at an average cost of US$9.2 capita (exclusive of the cost of the British team).

After the schemes were installed provision was made for future operation and maintenance. Revenue collections were organised to assist in financing the schemes.

The paper includes a review of the project achievements between 1976 and 1980 and conclusions and recommendations for similar programmes.

INTRODUCTION

In 1975, the Ethiopian National Water Resources Commission (NWRC), submitted a request for British aid to assist in the establishment of a regional office at Mekele in the Province of Tigrai (see Figure 1.). The aid team was also to prepare and implement pilot water supply schemes at six selected sites with the objective of determining detailed construction costs for each scheme and thus determine the best use of future funds available to the NWRC.

Subsequently, due to internal problems in Tigrai Province, the Commission submitted revised proposals to the British Government for a similar project to assist in the establishment of the Central Region office located in the capital, Addis Ababa, but with a general programme of design and implementation of rural water systems in the region.

This revised proposal was considered by the British Ministry of Overseas Development and, acting upon advice of the British Embassy, approval to proceed was given.

Sir M. MacDonald and Partners, Consulting Engineers of Cambridge, England, were appointed to provide the six man team for the technical assistance for the project. The members of this team, which was subsequently in 1978 increased to seven, and their inputs are shown on bar chart, Figure 2.

The capital aid provided by the British Government for the project was some £1.5 million which was divided into two equal parts. The first was to purchase equipment and materials to be imported from the United Kingdom and the other for local expenditures incurred during the project.

THE SETTING

The National Water Resources Commission divided Ethiopia into eight water resource regions, each with its own regional office, see Figure 1.

Central Region includes the whole of Shoa Province and also parts of Wollega and Arussi Provinces, and covers an area of nearly 100 000 km². Major rivers form the boundary on three sides of the region and numerous tributaries flow into these rivers from the central plateau usually in deep gorges. The main streams are mostly perennial but most of the minor ones cease to flow during the dry season.

The variation in landscape is remarkable; the region includes a large part of agricultural highlands, the most northerly group of the rift valley lakes and arid lowland areas of scrubland and semi-desert.

The rainfall pattern for three sites in the region is given in Table 1. The wet season occurs during the months June to September with a smaller amount falling in March, April and May.

Addis Ababa, the country's capital is located almost in the centre of the region and from it six major all-weather roads diverge into the countryside. These are the only all-weather surfaces and, during the wet season, much of the region is inaccessible. This means that any work programmes for the implementation have to be concentrated in the remaining dry months.

EXISTING SITUATION

The Central Region had an estimated rural population of five million in 1975 which was 20 per cent of Ethiopia's total rural population and, with a density of 50 per km², was the country's most densely populated region.

The people live in small size communities, scattered rather than concentrated, farming small fertile areas giving them a subsistence economy.

The people, mostly the female members of the households, travel long distances on foot to collect water for the families' daily needs. Understandably, with water being a rare and precious commodity, personal hygiene and therefore health suffers.

The provision of a water supply changes this situation and generally assists in the establishment of a better village life. The time made available to the women from reduced water carrying can be spent on cottage industries or in crop production and thus allows the low family incomes to be supplemented.

The first task of the technical assistance team upon their arrival in the region was to prepare an inventory of the existing water supply systems and thus establish a picture of both the present situation and future needs.

Because of the mountainous terrain to the north of Addis Ababa the area is fairly prolific in springs, shallow groundwater sources and perennial streams to provide the present population in most cases with an adequate water supply. For that reason the team concentrated its reconnaissance to the area south of the capital and 31 sites were inspected, details of the systems were catalogued and recommendations made for improvement.

The sites visited are shown on Figure 3, and Table 2 summarises the main features of the 31 systems inspected and gives some indication of the population of about 45 000 served by them.

Water is usually collected by the women in large - 20 litre - clay pots (enceras) although sometimes jerry cans or skins are used. Donkeys on occasion are employed but in the main the water is carried on the backs of women sometimes for distances as great as 15 km.

The policy adopted by the authorities is to charge for water from rural schemes at a rate of Ethiopian Birr 1.50/m^3. Thus a 20 litre unit costs 2.5 cents. However, the water seller's tickets are in units of 5 cents which does cause some confusion at waterpoints. The rural rate of Ethiopian Birr 1.50 should be compared with the metered rate for households in Addis Ababa which is 50 cents/m^3. During the period that the project was being carried out the rate of exchange for one US dollar was 2.07 Ethiopian Birr.

It is interesting to consider the reported revenue (1) and usage at Dengore (Nr 8 in Table 2) for the period July 1971 to June 1974. Revenues are summarised in Table 3 and the figures show that wet season demand is only about seven per cent of the dry season peak. The average dry season consumption is calculated to be around 11 litres per capita per day.

IMPLEMENTATION

When the aid team arrived in Ethiopia in 1976 the NWRC had just prepared a report (reference 2) which listed 343 communities in Shoa Province classified as being water needy. This report, which covered most of the Central Region area, emphasised that these communities were not the sum total of those requiring a water supply but only those identified as the most deserving and suffering an acute shortage. This 343 will give some indication of the problem which faces the NWRC in the task of providing rural water supplies in just one region of the country. It was from this report that the team selected sites for inclusion in the capital aid programme restricting selection to the really urgent cases.

With only limited funds available each year for the installation of new systems and the rehabilitation, operation and maintenance of existing ones it is obvious that guidelines are essential to determine which communities should benefit before others.

It is not possible to quantify many of the benefits that may be attributed to a rural water supply so that it would be speculative to attempt to rank communities in order to maximise social and economic benefits. As this is the case the Ethiopian NWRC set out a number of criteria for selecting the order of the work to be done. These were:-

(i) Community needs

- (a) size (large communities usually carry more risk of infection from water-associated diseases)
- (b) distance between the community and water sources currently in use
- (c) present quality of water
- (d) present quantity of water
- (e) presence of institutions (school, hospital, others).

(ii) Community potential

- (a) accessibility
- (b) role of community in government adminstration
- (c) presence of school
- (d) presence of health centre or health station
- (e) presence of agricultural extension work
- (f) other economic activities
- (g) existence of local water supply committee or similar
- (h) expected willingness and capability to contribute to the costs of the construction of the scheme in cash or labour
- (i) expected capability of the community to operate or assist in the operation of a scheme
- (j) expected capability of the community to contribute to the costs of operating a scheme.
- (k) expected contribution of a water scheme to increased economic activity.

(iii) System costs

- (a) size (economy of scale)
- (b) cost effectiveness of cheapest techniques in view of local geological and hydrological conditions
- (c) accessibility (all weather road, dry season road)
- (d) accessibility for drilling rigs
- (e) distance from NWRC regional office.

Besides the points mentioned above it must be realised that certain priority will always be given to obvious cases of hardship which necessitate urgent action and that systems with a low cost per capita will be attractive as the limited capital will be applied to the greatest effect.

Had detailed information been available for all the sizeable communities within the region it would have been possible, without too much difficulty to have carried out a ranking exercise although it would have been time consuming.

Without records the information for making any judgement must come from the local officials and obviously an active administrator aware of the water supply interests of the people under his jurisdiction will be more likely to achieve the early inclusion of his area in any region programme of implementation.

With so many communities to be provided with a water supply the need for a common approach to design practices became very apparent. In November 1976 the Rural Water Development Agency, NWRC, published Revised Design Standards for Rural Water Supply Systems for Communities up to 10 000 in Population. The aim of these standards was to provide a real but modest improvement in the accessibility to the people of a reliable water supply, of a better quality and increased quantity as near as possible to their homes. Limitations were accepted due to financial and manpower shortages but the need to reach as many people in as short a time as possible was paramount.

Briefly the standards included, inter alia, that:-

(i) some storage capacity be included to cover breakdowns
(ii) quantity of water per capita per day be set at 20 litres for communities up to 2500 and 25 litres for communities greater than 2500 but less than 10 000.

These figures are in line with both WHO data (reference 3) which show that consumption in African rural areas averages between 15 and 25 l/head/d and IBRD guidelines (reference 4) which regard between 20 and 100 l/head/d as appropriate.

With the establishment of the eight regions and the setting up of regional offices, the NWRC took the opportunity of preparing standard designs for the various components of a simple rural water supply system. The team assisted in the production of these designs which included waterpoint, generator house, pumphouse, standard compound layout, storage tank details, hand dug well details, cattle trough and so on. It was intended to include all these designs in a brochure of standard drawings which would be used in the other regions as they commenced implementation. Later editions of the brochure would be enlarged to include elements of a more sophisticated water supply.

The method adopted was to visit the site and prepare a proposal for the system and a cost estimate which had to receive the approval of donor government before capital aid funds could be dispersed. This procedure in no way hindered or slowed the implementation programme; with the initial programme being chiefly concerned with areas of potential drought it was natural that there was a tendency to concentrate initially on supplies from boreholes.

A standard layout for a borehole supply is given in Figure 4. The elevated storage tanks, 2 x $4m^3$, were prefabricated in Addis Ababa and transported to site.

The region has been well served with drilling rigs. Between five and seven available during the duration of the project and for this reason 26 of the 30 sites selected for development (see Figure 5) were supplied from boreholes, two from hand dug shallow wells, and two used spring capping as their source.

It is accepted that this inbalance was undesirable because supplies derived from a consistently increasing number of boreholes produces a corresponding increase in future operational problems and maintenance programmes. It is further admitted that whereas at some locations a borehole is perhaps the only solution a general shift to methods adopting simple technology should undoubtedly take precedence in the future.

Once a community had been selected for inclusion in the programme the site was revisited by the team's hydrogeologist to fix the exact location of the borehole. This was done with the full collaboration of local officials considering the geology and the distribution of the population to be served.

The drilling programme was prepared taking into account the drilling conditions and the type of rig (cable tool or rotary) available. Drilling was under the guidance of the highly experienced NWRC chief drillers with minimum supervision from the regional office and expatriate drilling superintendent. Each rig crew of usually ten men was supplemented by a technician to ensure that a record of each borehole was recorded and, where possible, samples taken at two metre intervals. On the first indication of water being reached the borehole remained under the close supervision of the drilling superintendent and the hydrogeologist until after development when the pump installation crew took over.

The depths of the project boreholes drilled and developed prior to March 1980 ranged from 47 to 180m. To meet the expected pump requirements, the project ordered from the United Kingdom 10 Pleuger submersible electrically driven borehole pumps covering three ranges of head from 150 to 300m and 20 Mono pumps, Types 620 and 641, driven by two sizes of Lister diesel engines for heads up to 125 and 200 respectively.

The existing NWRC practice was to install pumps by using the drilling or maintenance rigs.

It was considered that this custom inhibited the drilling programme and it was found possible to install the Mono pumps using a chain block. Although this method is time consuming it means the installation could be done by an independent crew permitting the rig to proceed to another drilling site.

With the submersible pumps the depths were usually greater and the rising mains were in 6 metre lengths so that the use of the drilling or maintenance rigs for installation could not be avoided. However, the procedure was straightforward and fairly quickly done.

One of the objectives of the groundwater programme was to record as much information of the aquifer characteristics as possible. The financial resources of the NWRC has not permitted the drilling of observation wells so that the team decided to use step-drawdown tests wherever possible followed by a conventional constant yield test in an effort to estimate the aquifer parameters. Step-drawdown tests cannot be done where electrical submersibles were installed.

At the Mono pump sites the drawdown in one hour for five different pump running speeds were observed. After these tests the water level with recovery levels was recorded. This series of tests was followed by constant yield test of at least 25 hours duration with the pumping rate selected after study of the drawdown testing. Recovery readings were also taken after this constant yield test.

The 30 sites approved for capital aid to March 1980 are shown in Figure 5. The region had seven construction teams led by an experienced construction foreman. Two of the crews specialised in hand dug wells and they used local people wherever possible so that the technology was passed on for future projects. Standard designs were used and local craftsmen quickly organised into efficient and willing teams to produce commendable standards of work and contributed greatly to the success of the project.

At 1 March 1980 the implementation was complete on 23 systems, in progress on two and ready to start on three others. On one other the borehole was dry and on another the fluoride content made the water unfit for human consumption. Table 4 shows the implementation costs at each site as at 1 March 1980. Including the expenditures at Dukem (9) and Jido (18) the table shows that some 107,500 people were provided with water at an average cost of Eth. Birr 19 (US$ 9.2) per capita.

UNIT COSTS

Because standard designs were used in the basic systems with only slight variations being made to suit individual site conditions; and with the cost accounting system set up within the Central Region Office it was possible to cost accurately the various construction elements. By the end of March 1979, 15 almost identical capital aid sites had been constructed and a summary of the major items is given in Table 5.

The basic supply system consisted of a borehole, elevated storage tanks, waterpoint structure, Mono pumphouse or generator house, fencing, hardstanding and where required a cattle drinking trough. The only real variable which affects the total cost is the depth and diameter of the borehole and the type of well casing used.

Table 6 shows the drilling performance of five rigs used at 17 different sites. The high drilling costs at the upper end of the range are a direct reflection of the problems encountered. At Kara Kore numerous cave-ins occurred and at Adami Tulu, because of serious breakdowns due to equipment failure, work stopped for almost four months. At the opposite end of the scale, ideal drilling formations and exceptional drilling performance combined to produce extraordinarily low rates. If the two sites at the top and bottom of the range are ignored then we have average drilling costs for 150mm diameter steel or ABS plastic of Eth Birr 165 per linear m.

The average cost per linear metre for each of the rigs can also be established using the same procedure. These are:-

i)	Portadrill	Eth Birr 142/linear m
ii)	Walker Nerr	Eth Birr 155/linear m
iii)	Speedstar	Eth Birr 155/linear m

iv)	Failing 1500 (Nr 1)	Eth Birr 169/linear m
v)	Failing 1500 (Nr 2)	Eth Birr 173/linear m

Pipelaying rates at Addis Alem, Bulbula and Meki Town were also analysed for use in future estimating by the NWRC.

With the rates obtained during the project implementation, the NWRC should be able accurately to estimate costs of proposed work, especially that located in the Central Region.

OPERATION AND MAINTENANCE

Upon the completion of the construction work the commitment of capital aid funds to a particular site ceased, all future expenses incurred as a result of the operation and maintenance of the waterpoint being the responsibility of the NWRC. The aid team, until their departure, assisted in ensuring that the sites continued to operate successfully.

The first step was the appointment of the necessary officials to be responsible for the day to day control, management and operation. Usually two officials were required, one to tend the pumping machinery and the other to supervise the waterpoint and collect the revenue. Normally three or four days instruction were given by staff of the regional office. The monthly salary of these two operatives in 1979 was in the order of Eth Birr 70 per month and as they were recruited from the local communities they invariably had other means of subsidising their income. This often resulted in an inefficient and irregular operation of sites. One suggestion that was proposed was that a water users committee be established at sites because the committee with a vested interested would achieve a more successful operation than the distant regional office control.

One of the responsibilities of the revenue collector is to supervise the operation of each site and to keep the regional office fully acquainted with problems and the defects as they arise. Each site is visited at least once a month and in addition to the routine tasks of receiving the revenue collected and recording the water meter reading the collector is also expected to report upon the general condition of the equipment and the site. Knowing the number of tickets sold by the local supervisor and the meter reading, it is simple to keep a close check on both revenue and water use. The aim of the NWRC is that the revenue collected is sufficient to cover the operation and maintenance costs of the rural sites. It is also the revenue collector's responsibility to keep the sites supplied with the necessary fuel for the pumping machinery.

Prior to the project the emphasis was on water supply from borehole sources, so that an early introduction of a parallel programme of maintenance to the related equipment was essential. Unfortunately no such programme had been introduced and as long as sites remained operational they were neglected. Reports of breakdowns filtered back to the Head Office in Addis Ababa by way of the revenue collector and in cases of emergency it was not unknown for the operators themselves to travel back to Addis Ababa in order to make a personal report and representation.

With only limited resources available, taking action on these reports and effecting the necessary repairs could then take an indeterminate length of time.

Following the establishment of the Central Region, the maintenance of all existing and future sites was naturally made the direct responsibility of the regional office. Initially, however, the facilities with which to effect the repairs and maintenance were almost non-existent. There was a steady improvement of this position over the last two years of the project and by mid-1979 the region was equipped with two mobile workshops (one provided through the programme of capital aid and the other by the UNDP), each engaged on independent programmes of preventive maintenance and in addition a maintenance rig was available for use during the maintenance or replacement of pumps.

With the introduction of Mono pumps as the standard installation it was anticipated that maintenance programmes would become much easier in the future as the crews of the mobile workshops become increasingly familiar with their work. It should then be possible for each site to be the subject of some form of maintenance work in the order of once every six weeks, the likelihood of serious breakdowns consequently being considered reduced.

Standardisation also resulted in a more effective back up service from the regional office, for the storage of a wide range of spare parts for different pumps and so on became unnecessary. Mono pumps also appointed a local agent in Addis Ababa who it is hoped can be induced to carry the full range of spares. This will greatly assist in the establishment of an efficient maintenance service.

ESTABLISHMENT OF REGIONAL OFFICE

The duties of the aid team included the building up of a regional office to serve Central Region and formulation and implementation of administrative, financial and operation procedures which should be applicable to other regional offices. When the team arrived in 1976 temporary office accommodation was obtained, albeit rather too small to house the staff, stores and provide parking for all the project vehicles. The new offices were not built while the aid team was in Ethiopia since it was 1979 before the necessary site had been released and the architects had completed the building plans. Construction of the stores and workshops were started in 1979 but the actual office was not started until 1980 after the last member of the aid team had left Central Region. Fortunately the British Government agreed to fund the building of this office even though the project had officially finished. It was planned that the Central Region staff would move into their new offices in late 1983.

With respect to the formulation and implementation of office procedures, the existing administration and financial ones in use by the NWRC were adopted in the Central Region office while the means of improving of the existing system plus the application of a new cost accounting system was studied and put into operation.

The necessary forms required for the new costing system were approved in March 1977 after extensive discussion between the team's administration officer and the NWRC staff at both regional and head office level.

During the project all the procedures were reviewed, revised and where necessary, due to changes in government regulations, new ones were introduced. Hence an efficient overall office and accounts routine was evolved.

In general, the accounts system devised conformed with corporate organisation accounting practice with the exception that fixed asset compilation and depreciation was not introduced. The accounts system provides the data to enable these following functions to be carried out:-

i) recording of financial transactions;
ii) reporting the result of financial transations;
iii) preparing reports for management for central purposes;
iv) preparing reports for Government;
v) checking the recording and report of financial data;
vi) interpreting financial and managerial reports;
vii) determining and controlling the costs of production.

It should be stressed that even with system introduced, it is not possible accurately to assess the true cost of water produced in the rural areas of the region because of the lack of fixed asset data and depreciation.

The organisational chart for the Central Region administration section is shown in Figure 6. The following brief notes define the work which is the responsibility of each section.

a) Finance
i) General accounts - cash book payments and general accounting forms;
ii) Budget - general accounting procedures as prescribed by the Ministry of Finance for government departments;
iii) Cost accounts - cost accounting.

b) General services
i) Procurement - purchasing of all materials for stock;
ii) Stores - storekeeping, stores records and safe custody of all materials;
iii) Archives - maintenance of all records, and filing of letters and documents;
iv) Support services - office messengers, cleaners, guards and gardeners.

c) Personnel
i) Recruitment - responsible for advertising, interviews and employment of all staff in close liaison with Head Office, NWRC;
ii) Staff relations - responsible for personnel management;
iii) Records - maintenance of all personnel records.

The designation and number of Central Region staff is given in Table 7.

CONCLUSIONS AND RECOMMENDATIONS

The object of the project, to establish the Regional Office, prepare an inventory of the existing systems and then to design and implement a general water supply programme was achieved. At the end of February 1980, 23 schemes had been completed, two were under construction and designs prepared for three others. One scheme was abandoned due to a dry borehole and another because of the high fluoride content of the water.

The inspections of existing systems showed that there had been no uniformity of construction prior to the establishment of the Regional Office. At a number of sites the watering of animals close to the domestic watering point was a contamination risk. Maintenance had been minimal and the main water source, groundwater, was undevised.

The need for an educational programme in the use of water is extremely important so that an improved standard of health can be achieved. The best place to start this programme is in the schools and this was recognised by both the ministries of education and health in May 1976 (reference 5).

Encouragement and support should be given to simple self-help projects in the field of rural water supply. This has two advantages; first the cost of implementation is reduced and second the community has a pride in the finished system because it assisted in building it. For self-help projects to be a success it means that, as far as possible, simple technology must be adopted and that the communities are assisted in the design and planning at a very early stage by the technical staff from the Regional Office. The same applies to the renovation, rehabilitation and extension of existing systems. With community participation the available funds can be more effectively used.

No matter how well a system may be designed it cannot continue operating successfully unless it is well maintained and that the spares necessary to keep it running are readily available. This highlights the need that any project being funded requires not only the proper plant and equipment for implementation but even more important, the plant, tools and spares to ensure that the completed systems can be maintained in the future. To help achieve this it is desirable to attempt to standardise on plant, equipment and vehicles so that the number and range of spares that need to be carried in the stores is a minimum. Unfortunately in most cases rural water supply projects are usually funded as bilateral aid or from the main international financing agencies and the plant, equipment and vehicles are not those which the recipient would have ordered had the choice been his alone. This results in a multiplicity of spares being required and because developing countries usually have a short fall of foreign exchange, it is impossible for them to purchase all the stores and spares to cover every eventuality and hence any maintenance programme must suffer. It is therefore essential that any project funding fully recognises the operation and maintenance needs and that sufficient spares are provided by the funding to ensure continued operation of the systems built.

ACKNOWLEDGEMENTS

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4. International Development Association — Ethiopian water supply and sewerage study, document of International Bank for Reconstruction and Development, Report Nr. 309 - E,T 8.1.1974

5. Ministry of Health, Ministry of Education — Water Education Project, Seminar in Addis Ababa, May 1979

6. Sir M. MacDonald & Partners — Ethiopian Central Region Rural Water Supply, Final Report, September 1979 and Addendum, June 1980.

TABLE 1 Monthly rainfall distribution (mm) for three stations

(1)

Station, Addis Ababa: latitude, 09°02'N; longitude, 38°45'E; elevation, 2408m; period, 1966/75.													
	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL (3)
High	43	139	232	229	201	146	303	435	270	50	60	53	143
Low	0	0	2	9	4	86	190	184	115	0	0	0	977
Mean	21	60	43	85	114	132	265	330	182	8	4	0	1260

(2)

Station, Sululta: latitude, 09°11'N; longitude, 38°46'E; elevation, 2610m; period, 1974/77.													
	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL (3)
High	110	24	53	89	117	242	448	311	148	175	57	12	1527
Low	0	3	27	61	70	129	271	231	60	6	0	1	1132
Mean	38	17	37	88	97	183	361	296	130	18	0	0	1402

(2)

Station, Mekal Meda: latitude, 10°14'N; longitude, 39°41'E; elevation, 3030m; period, 1974/77.													
	J	F	M	A	M	J	J	A	S	O	N	D	TOTAL (3)
High	30	18	43	55	82	84	565	396	201	284	30	2	1525
Low	0	2	0	0	17	13	179	92	47	6	0	0	581
Mean	6	16	42	38	64	63	306	332	78	21	22	0	727

Notes:- (1) Only part year records were available for 1974 and 1975.
(2) Only part year records were available for 1974.
(3) High, low and mean yearly figures.

TABLE 2 Facilities at existing water supply sites

NWRC priority Nr.	Site	Population served	Generator house	Storage tank	Water point	Cattle trough	Laundry point	Perimeter fence
1	Feto	1000	-	*	*	*	-	*
2	Ket Bere	300	-	*	*	*	-	*
3	Tulu Bolo	3500	*	*	*	-	-	*
4	Welkite	5000	-	*	**	-	*	*
5	Bora 2	1000	*	*	*	*	-	*
6	Kombolcha	500	*	*	*	*	-	*
7	Dugda 1	400	-	*	*	*	-	*
8	Dengore	3000	-	*	***	*	*	*
9	Dire Cheleba	500	*	*	*	-	-	*
10	Wajitu	1000	*	*	*	-	-	*
11	Bora 1	500	-	-	*	*	-	*
12	Dugda 2	700	-	*	*	*	-	*
13	Tora	600	*	*	*	*	-	-
14	Bolo Giorgis	1500	-	*	**	*	-	*
15	Menjar Ararti	2000	-	*	**	-	-	-
16	Ilala Ber	500	-	*	*	*	-	-
17	Choba Chore	2000	*	*	**	*	*	-
18	Cheleba Selassie	500	-	*	*	*	-	-
19	Ejersa Lale	200	-	-	*	-	-	-
20	Koshe	2500	-	*	**	*	-	*
21	Bui	3500	-	*	*	-	-	-
22	Goro	400	*	*	*	-	-	-
23	Gurura	400	-	*	*	-	-	-
24	Mitto	4000	-	*	*	-	-	-
25	Dilela	700	-	*	*	-	-	*
26	Waig	400	-	-	*	*	-	-
27	Genet	3500	-	*	**	-	-	*
28	Melka Jilo	500	-	-	-	*	-	-
29	Abosa	400	-	-	-	-	-	*
30	Addis Alem	4000		Water supply scheme				
31	Daleti	200		No recommendations at the present time				

TABLE 3

Monthly revenue in Ethiopian Birr from Dengore water supply site

Month	1971/72	1972/73	1973/74
July	200*	200	100
August	200*	150	50
September	200*	50	50
October	200*	50	100
November	200*	600	650
December	250	850	550
January	800	1000	600
February	900	1000	800
March	1000	1000	1000
April	500	900	900
May	350	500	400
June	200	100	150**
Total	5000	6400	5350

Source: NWRC Report (1)

Notes:

* It is possible that these figures are on the high side since the revenue collector paid Eth. Birr 1000 at the end of November for the period covering July to November but it is possible that some revenue for June was also included.

** This figure is an estimate.

Identified sites by British geological survey team

TABLE 4

Approved capital aid sites (March 1980): Implementation costs (Eth Birr)

Nr.	Location	Estimated cost	Final cost	Estimated population	Cost per capita*
1	Kara Kore	125 816	240 243 (a)	5 000	60
2	Senbete	67 500	68 619	2 500	46
3	Meki Town	82 000	102 344	10 000	16
4	Meki	123 635	130 072	20 000	16
5	Addis Alem	92 564	236 588	6 000	66
6	Kessem Kabana	55 895	66 530	10 000	16
7	Ankober	56 000	Awaiting Start	1 500	-
8	Adami Tulu	76 250	84 866	4 000	35
9	Dukem	86 000	18 000	(4 000)	-
10	Mati and Dalota	68 900	61 642	4 000	26
11	Radi	56 300	54 499	4 000	23
12	Korkie	69 820	66 509	6 000	18
13	Abusera	101 800	75 229	3 500	36
14	Roketti	98 300	77 555	3 000	36
15	Dengore Ney	98 300	80 070	4 000	33
16	Mermersa	71 500	62 387	2 000	52
17	Bulbula	66 400	76 540	2 500	51
18	Jido	53 300	15 802	(2 500)	-
19	Faka and Repi	90 000	90 375	2 000	75
20	Hanna Mariam	60 250	45 620	2 000	38
21	Dewara Gudo	63 250	52 693	2 000	44
22	Bika	70 000	61 702	1 500	69
23	Tora	73 000	~~Awaiting Start~~	3 500	-
24	Bora Mariam	79 000	76 362	2 500	51
25	Abernosa	68 900	55 223	3 000	31
26	Kawa and Gerussue	75 800	Awaiting Start	2 500	-
27	Alem Ketema	100 750	71 751(a)	6 000	18
28	Metcha Boreda	71 250	Drilling in Progress	2 000	-
29	Rasa Guba	65 600	Drilling in Progress	3 000	- 115 m dry hole deep
30	Muda	68 500	68 500(e)	2 000	57
	TOTAL	2 336 580	2 039 721	120 000	

Notes:

Implementation costs for the distribution systems at Kara Kore (1), Addis Alem (5) and Bulbula (17) were considerably in excess of the estimate as a result of the high cost of bringing the mateials to Ethiopia by air charter.

Dukem (9) borehole was dry and Jido (18) was not developed because of high fluoride content.

(a) To date
(e) Estimate
* Based on estimated users at the site

1982: x 40%

TABLE 5

Unit Cost of items at Capital aid sites (1979 Price)

(excluding well)

2 Eth Birr ~ 1 US $

Item	Cost (Eth Birr)
Mono pump and motor	17 320
Plueger pump and generator	23 835
Waterpoint structure	2 550
2 x 4 m^3 steel storage tanks	7 790
Mono pumphouse and store shed	3 490
Generator house	3 015
Cattle trough	3 980
Fencing and hardstanding	2 730

TABLE 6 Drilling performance of rigs with unit costs

Nr	Site	Rig	Depth (m)	Casing	Casing cost (Eth Birr)	Drilling cost (Eth Birr)	Total cost (Eth Birr)	Rate/linear m (Eth Birr)
17	Bulbula	F1	71	150 mm B	2 219	1 837	4 056	57.1
19	Faka and Repi	WN	161	150 mm B	5 351	9 371	14 722	91.4
24	Bora Mariam	WN	161	150 mm A	12 708	3 343	16 052	99.7
13	Abusera	P	180	150 mm B	7 522	12 043	19 565	108.7
25	Abernosa	F1	75	200 mm B	2 967	5 540	8 507	113.4
22	Bika	WN	121	150 mm A	8 814	6 471	15 285	126.3
12	Korkie	F2	125	150 mm B	4 079	12 547	16 626	133.0
21	Dewara Gudo	P	83	150 mm A	6 218	5 991	12 209	147.1
16	Mermersa	WN	135	150 mm B	5 642	14 989	20 630	152.8
2	Senbete	SP	79	150 mm B	2 578	9 692	12 270	155.3
14	Roketti	P	160	150 mm A	12 276	15 723	27 998	175.0
10	Mati and Dalota	F2-P	110	150 mm A	8 926	13 762	22 688	206.3
11	Radi	F2	70	150 mm B	2 285	12 677	14 963	213.8
18	Jido	F1	66	150 mm B	2 137	12 566	14 693	224.3
15	Dengore Ney	WN	130	150 mm A	10 545	20 914	31 459	242.0
8	Adami Tulu	F1	99	150 mm A	6 234	28 091	34 325	346.7
1	Kara Kore	SP	47	150 mm B	2 549	30 358	32 907	700.2

Notes:
Rig F1 - Failing 1 500 rotary (Nr 1)
Rig F2 - Failing 1 500 rotary (Nr 2)
Rig WN - Walker Neer cable tool
Rig P - Portadrill rotary
Rig SP - Speedstar cable tool

A = ABS plastic
B = Steel

Table 7 Central region staffing (September 1979)

Nov. (1982)

Designation	Nr of staff*
Administration:	
Regional manager	1
Secretary/typist	1
Administrator	1
Administrative clerk	1
Accountant	3
Personnel clerk	1
Project preparation:	
Assistant engineer	1
Hydrogeologist	1
Draughtsman	2
Secretary/typist	1
Technicians	40
Project construction:	
Construction supervisor	8
Drilling superintendent	1
Drillers	8
Assistant drillers	6
Drilling crews - staff	31
Construction crews - staff	6
Electrician	1
Mechanic	2
Plumber	3
Mason	9
Carpenter	7
Maintenance crews - staff	8
Project operation:	
Revenue collector and fuel supplier	1
Assistant revenue collector and fuel supplier	1
Fee collector	29
Pump attendant	25
Drivers	14
Truck drivers	4
Messengers	2
Cleaners	2
Guards	4
Project workshop and garage:	
Workshop foreman	1
Mechanic's helper	1
Welder	2
Workshop assistant	1

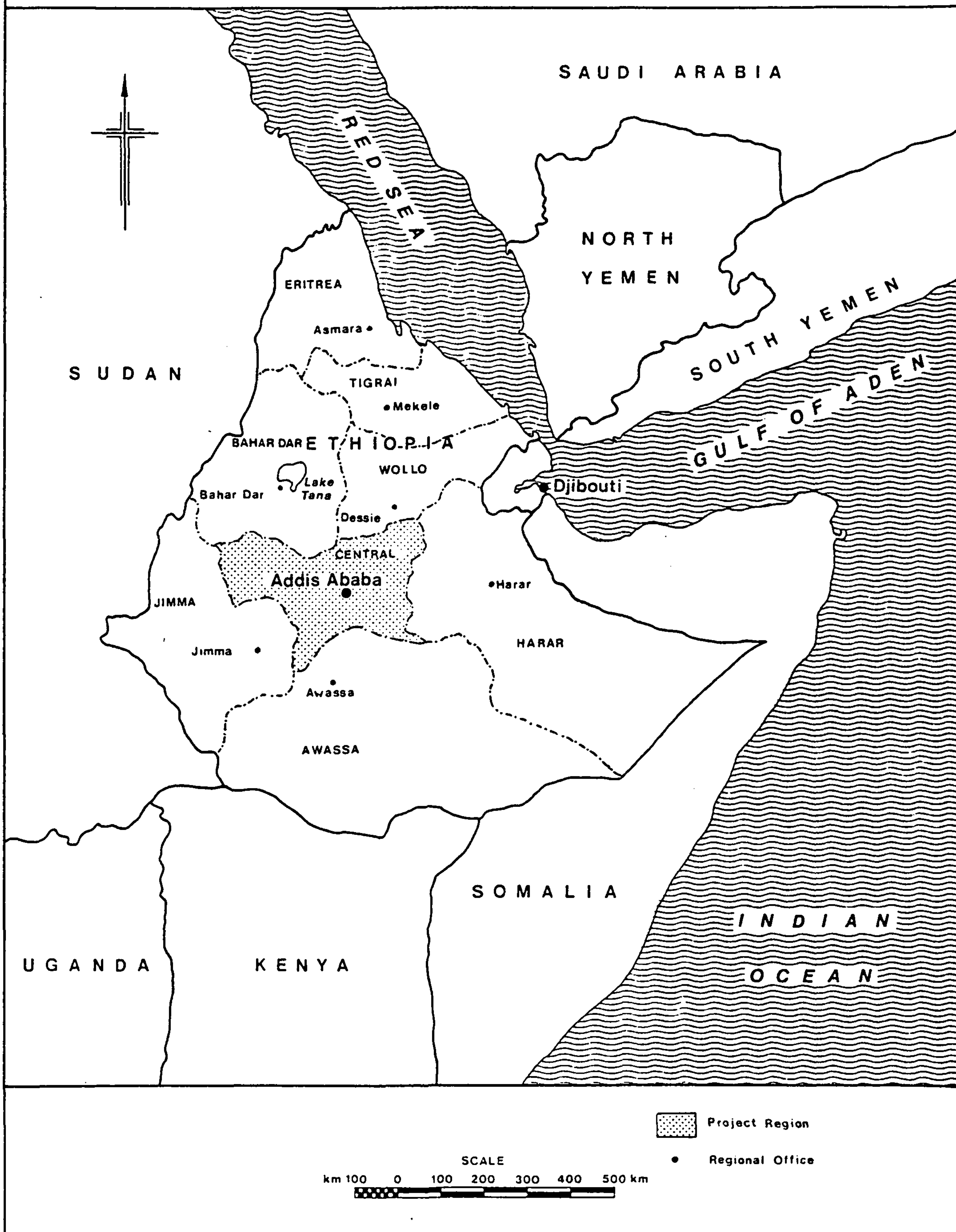
Designation	Nr of staff*
Project stores:	
Head of procurement and stores	1
Assistant storeman	2
Purchaser	1
Hydrographic records:	
Hydrographers	8
Gauge readers	64
Total number of staff (September 1979)	306 [illegible]

Note

* Total number made up of staff either provided by NWRC or recruited and paid for by capital aid funds

Figure 1

PROJECT LOCATION & WATER REGIONS



Staffing Programme

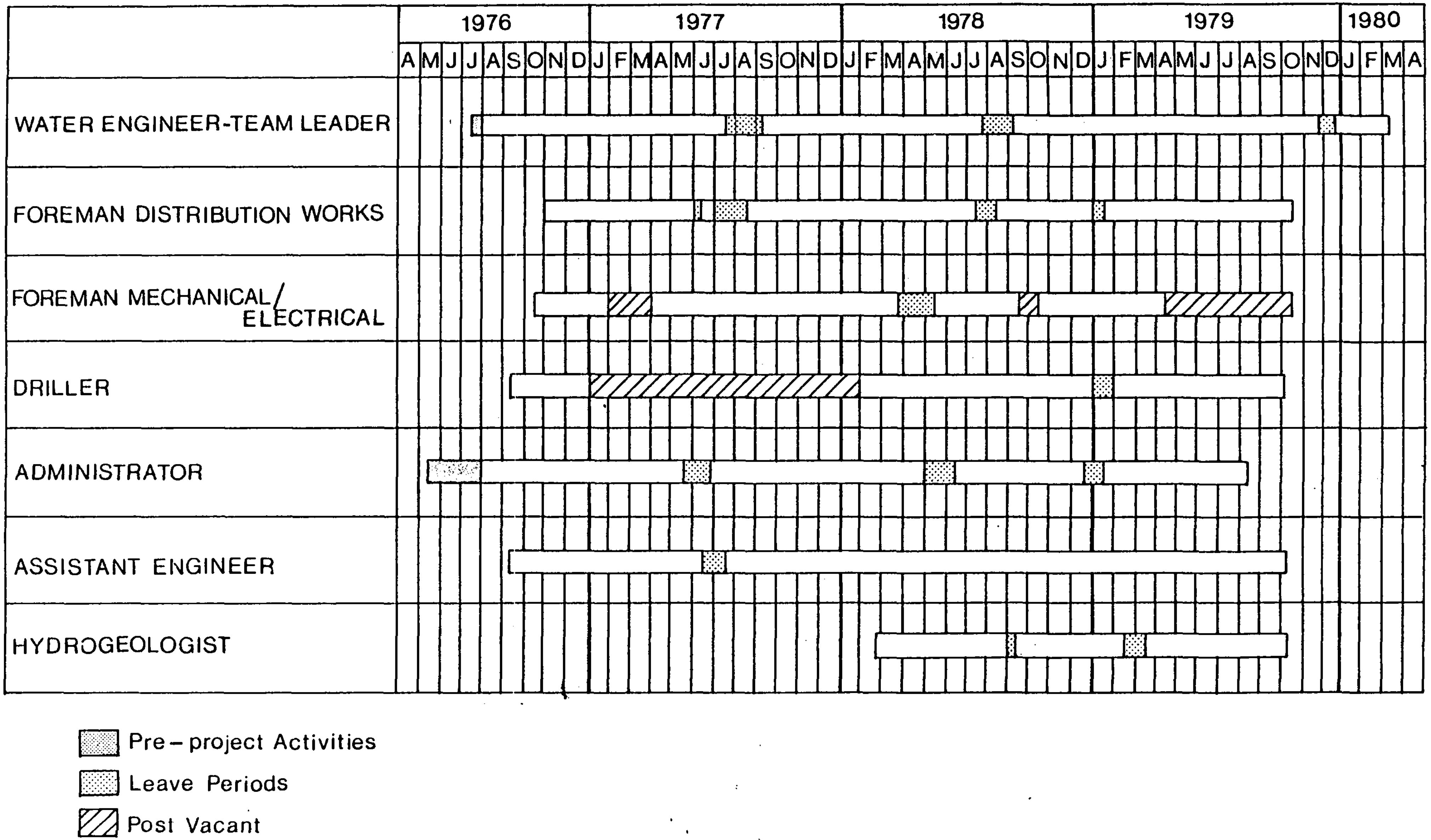


Figure 2

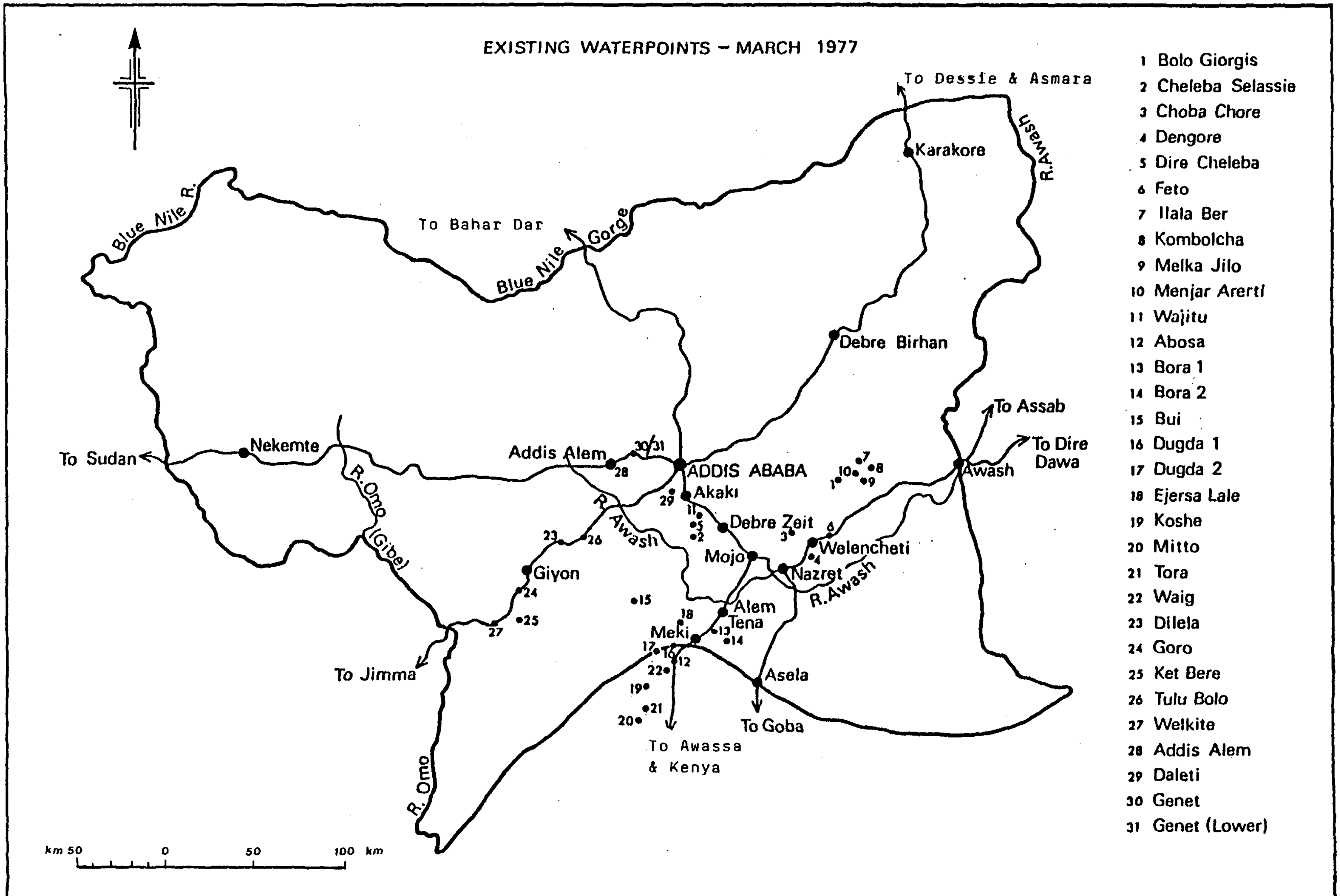
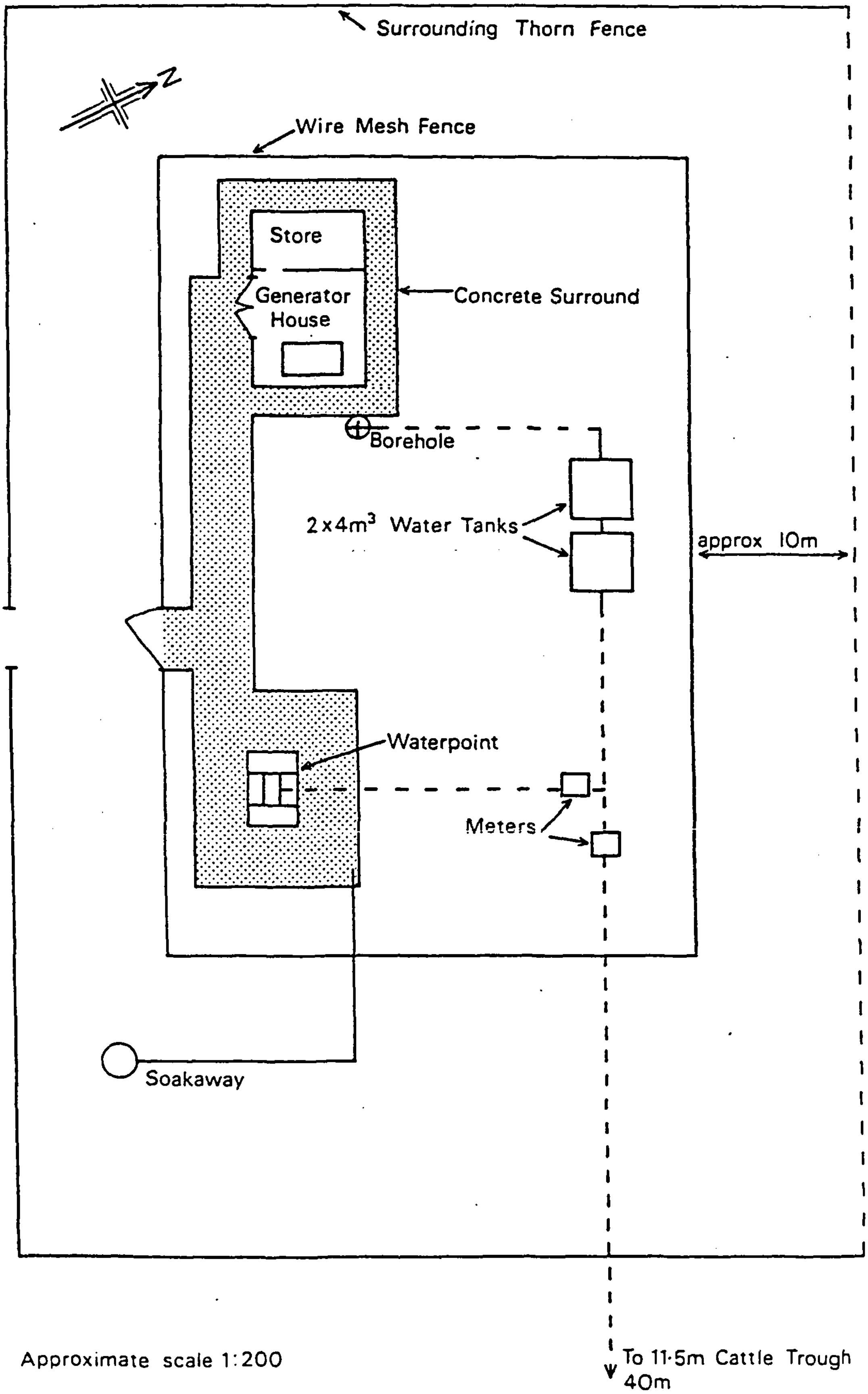

EXISTING WATERPOINTS – MARCH 1977
To Dessie & Asmara
Karakore
R. Awash
Blue Nile R.
To Bahar Dar
Blue Nile Gorge
Debre Birhan
To Assab
To Dire Dawa
Awash
To Sudan
Nekemte
R. Omo
Addis Alem
ADDIS ABABA
Akaki
Debre Zeit
R. Awash
R. Omo (Gibe)
Giyon
Mojo
Welencheti
Nazret
R. Awash
Alem Tena
Meki
Asela
To Jimma
To Goba
To Awassa & Kenya
R. Omo
km 50 0 50 100 km
1 Bolo Giorgis
2 Cheleba Selassie
3 Choba Chore
4 Dengore
5 Dire Cheleba
6 Feto
7 Ilala Ber
8 Kombolcha
9 Melka Jilo
10 Menjar Arerti
11 Wajitu
12 Abosa
13 Bora 1
14 Bora 2
15 Bui
16 Dugda 1
17 Dugda 2
18 Ejersa Lale
19 Koshe
20 Mitto
21 Tora
22 Waig
23 Dilela
24 Goro
25 Ket Bere
26 Tulu Bolo
27 Welkite
28 Addis Alem
29 Daleti
30 Genet
31 Genet (Lower)

Figure 3

Figure 4

SITE PLAN FOR MERMERSA (16)



Approximate scale 1:200

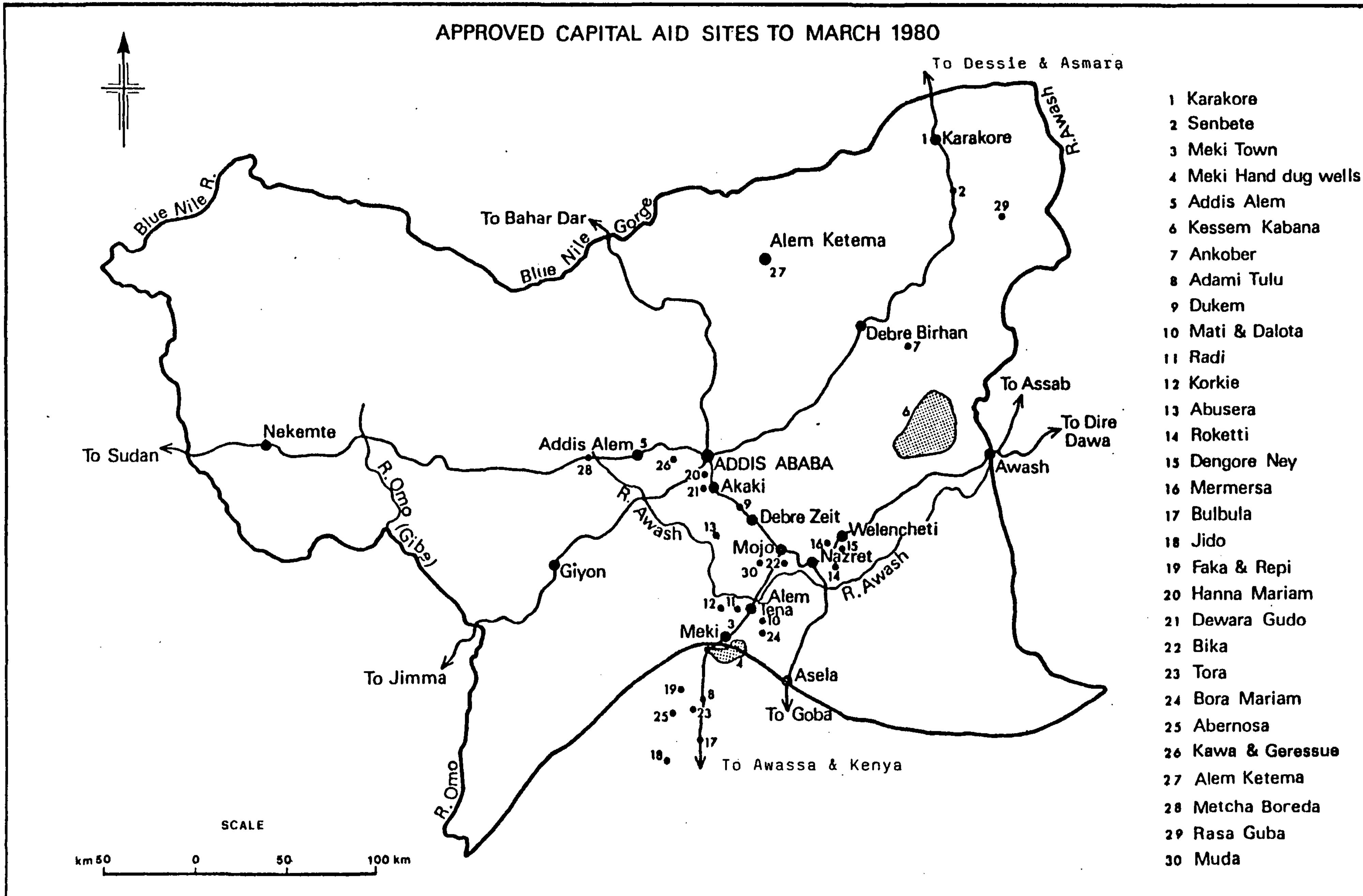
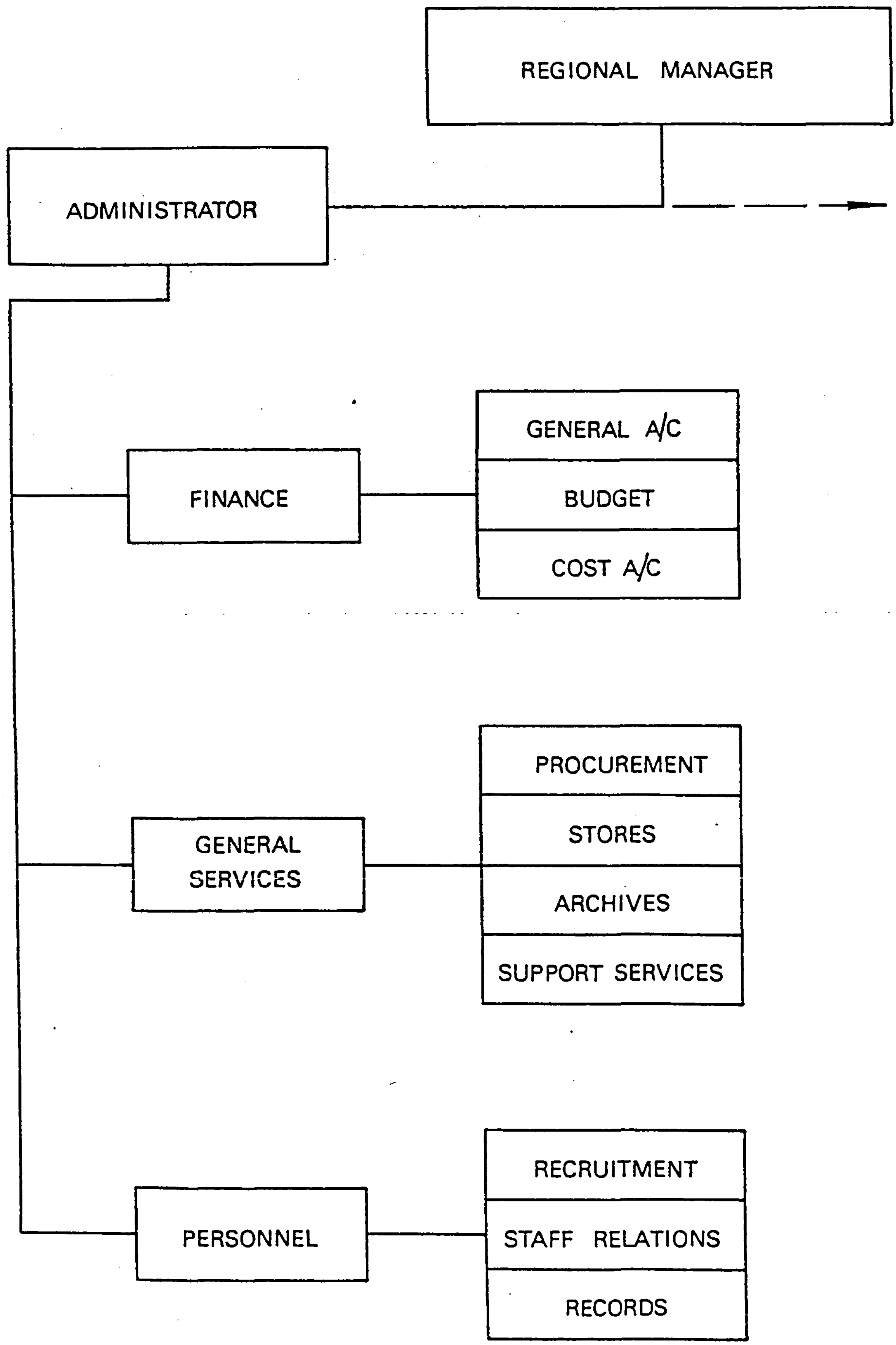
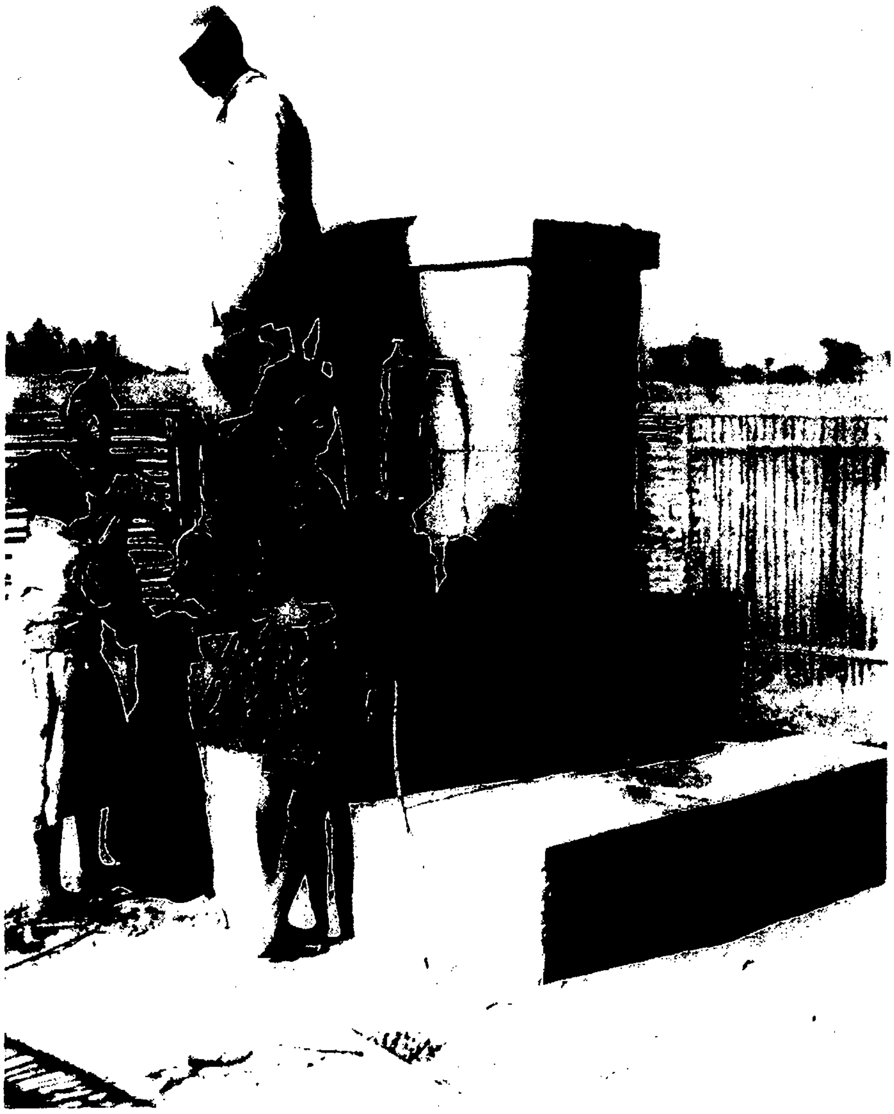

APPROVED CAPITAL AID SITES TO MARCH 1980
To Dessie & Asmara
Karakore
R. Awash
Blue Nile R.
To Bahar Dar
Blue Nile Gorge
Alem Ketema
Debre Birhan
To Assab
To Dire Dawa
Nekemte
To Sudan
Addis Alem
ADDIS ABABA
Akaki
Debre Zeit
Welencheti
Awash
R. Omo
R. Omo (Gibe)
R. Awash
Mojo
Nazret
Giyon
Alem Tena
Meki
Asela
To Jimma
To Goba
To Awassa & Kenya
SCALE
km 50 0 50 100 km
1 Karakore
2 Senbete
3 Meki Town
4 Meki Hand dug wells
5 Addis Alem
6 Kessem Kabana
7 Ankober
8 Adami Tulu
9 Dukem
10 Mati & Dalota
11 Radi
12 Korkie
13 Abusera
14 Roketti
15 Dengore Ney
16 Mermersa
17 Bulbula
18 Jido
19 Faka & Repi
20 Hanna Mariam
21 Dewara Gudo
22 Bika
23 Tora
24 Bora Mariam
25 Abernosa
26 Kawa & Geressue
27 Alem Ketema
28 Metcha Boreda
29 Rasa Guba
30 Muda

Figure 5

Figure 6

CENTRAL REGION ORGANISATIONAL CHART
ADMINISTRATIVE SECTION





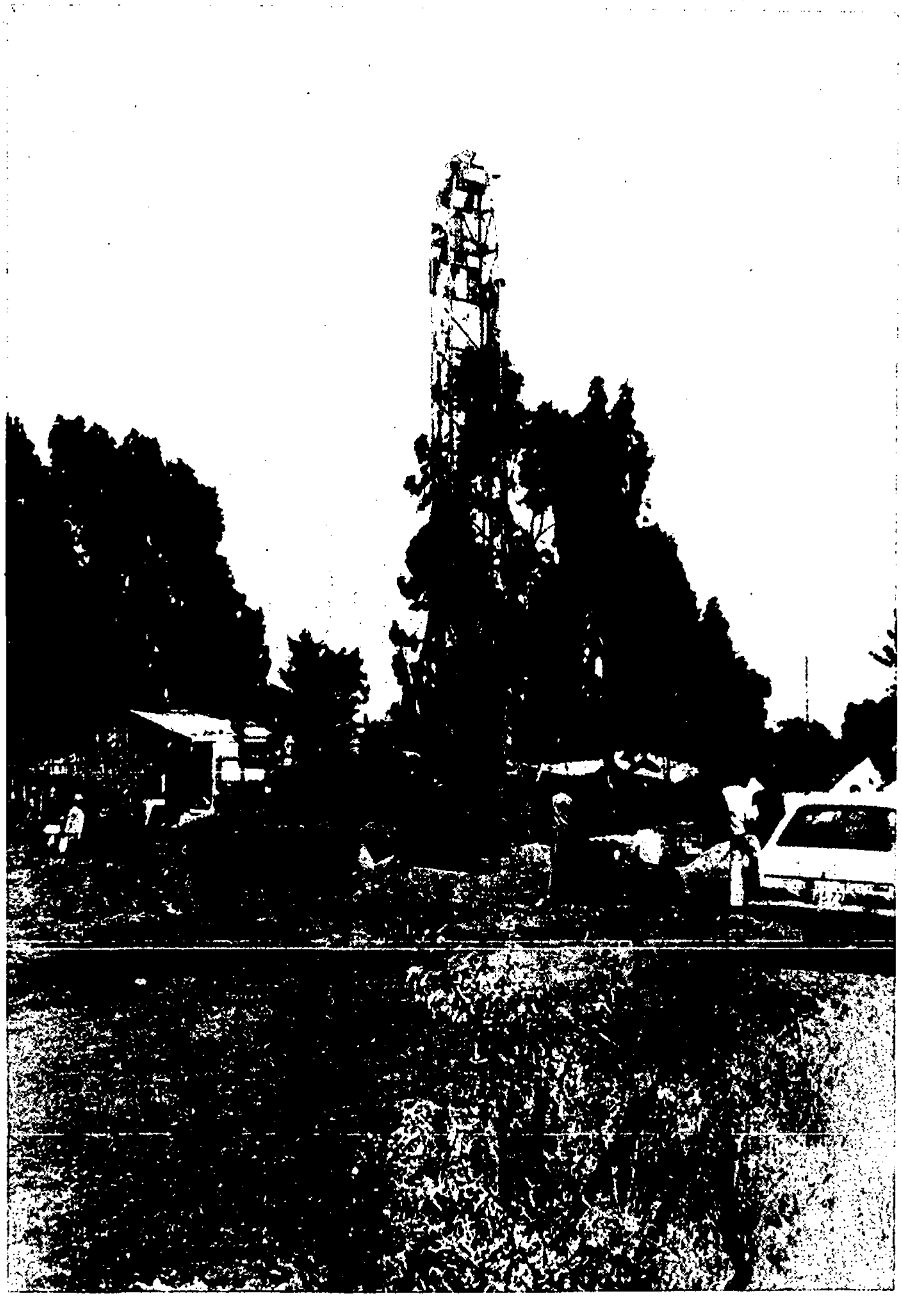
Waterpoint at Muda capital aid site, February 1980.

Water seller filling water container on donkey,
Bulbula River, July 1978

Water collection point from spring source,
Ankobar, June 1978

Enceras - 20 litre pots.
Note grass plug to prevent spillage; Tora, June 1978

Self help. Pipeline excavation by villagers at Kara Kore; 1979



Drilling at Dukem

Completed capital aid site at Faka and Repi, February 1980

Construction (concreting) of top slab for dug well site, Meki

Constructing well linings for hand dug well sites, Meki

Hand pump capital aid site, Meki, 1979

PAPER 5

WATER SUPPLY IN THE JONGLEI AREA OF SOUTHERN SUDAN - A CHANGING STRATEGY

BY

J.J. WADLEY, PARTNER

and

D.I. AIKMAN, PROJECTS ENGINEER

BABTIE SHAW AND MORTON, U.K.

SYNOPSIS

This paper describes the present water supply facilities in the Jonglei Canal area which forms part of the Upper Nile Region of the Democratic Republic of the Sudan.

It also describes a phased water supply programme for the area based on the philosophy that water supply to remote rural areas should be capable of being operated and maintained for long periods by relatively unskilled personnel without external assistance and supplies, particularly of fuel; be supported by a sound, adequately funded operation and maintenance organisation.

The paper also argues that the standard of access to water supply points should be a major determinant in the selection of the water supply system to be adopted; that health education is essential if the benefits of improved water supply are to be realised; and that direct charging for water often results in the continued use of polluted waters.

INTRODUCTION

1.1 ORIGIN OF STUDY

The Jonglei area covers some 68,000 km² of land including approximately 18,000 km² of permanent swamp (the Sudd) and lies in the upper catchment of the river Nile in Southern Sudan (Figure 1). The Bahr et Jebel (White Nile), runs through the swamp and loses approximately half its average annual discharge on the way as a result of evaporation processes.

Plans to bypass the swamp and thereby increase the quantity of water available for human use and improve the navigability of the river reached maturity in 1978 with the start of construction of the 360km long Jonglei Canal.

With a view to planning developments which might ameliorate any adverse effects of the canal, and would at the same time take advantage of the development impetus of the canal as an all weather access into the area, the government of Sudan in conjunction with the European Economic Community financed an ecological and engineering study of the area. Water supply for both people and livestock formed an important element of this study (reference 1).

The work was carried out between 1979 and 1983 by Mefit-Babtie, a joint venture between the Italian firm, Mefit SpA of Rome, and British consulting engineers, Babtie Shaw & Morton of Glasgow.

1.2 WATER RESOURCES

The Jonglei area can be described as an extremely flat alluvial plain sloping gently northwards and broken only by repeated patterns of shallow depressions. Mild undulations of the order of a few tens of centimetres deep and commonly more than 100 metres wide give rise to an extensive pattern of drainage depressions or khors.

The only permanent water courses are the rivers Bahr el Jebel and Bahr ez Zeraf to the west, and the rivers Nile and Sobat to the north (Figure 2).

The average annual rainfall is in the region of 800 to 900 mm with more than 80 per cent of the total normally falling in the six months May to October (the wet season). River levels also rise to a maximum in this period. Annual evaporation at more than 2000 mm greatly exceeds rainfall in all but the wettest months.

The very flat land slopes combined with relatively impermeable soils result in extensive flooding from both rivers and rainfall during the wet season. The pools thus derived form the major source of water for both people and livestock during the first part of the dry season. By contrast, during the latter part of the dry season, there is a considerable shortage of surface water in all areas distant from the rivers.

Groundwater is widely available with water table depths generally in the range 15m to 55m, although water is also seasonally available at depths of 3m to 12m in certain localised areas. The aquifers comprise layers of fine to coarse granular material set in a predominantly clay sequence.

The quality of waters is very variable depending on the source and location of supply. In general, surface waters can be considered to have a high concentration of suspended solids and bacterial pollutants and a low concentration of dissolved solids. Groundwater can be considered of better bacterial quality, however excess salinity (greater than 1500 parts per million) limits the usefulness of this source in localised areas in the south and, more importantly, over the northern third of the area.

1.3 PEOPLES

Three major groups of people live within the study area, namely, Dinka, Nuer and Shilluk. The first two groups, who comprise the majority of the population, are semi-nomadic pastoralists. The Shilluk, whose way of life is more static, are confined to the north-east corner of the study area and are effectively outside the area considered for water planning purposes.

The movement of the Dinka and Nuer pastoralists is determined by the availability of water and grass. All the people and cattle live in or close to permanent settlement areas in the wet season while some 50% of the people and a lesser proportion of the livestock may remain there throughout the dry season (reference 1). The young men drive the cattle through distances of up to 60km to utilise the water and associated grasslands of the seasonally flooded areas.

1.4 INFRASTRUCTURE

Permanent settlements comprise a number of thatched dwellings widely dispersed over several square kilometres (Figure 2), thus even in relatively populous areas, population densities are estimated to average less than 300 persons per square kilometre (reference 1).

The only townships of any size are Bor in the south and Malakal in the north. This latter town is outside the administrative boundary of the area considered for water planning purposes and is not considered further here. A small number of the administrative centres located on the main roads have developed limited street patterns bordered by shops and dwellings and as such may also be described as townships. By virtue of the closer spacing of dwellings, the population densities in the towns are somewhat higher than in the rural areas. Within the Jonglei areas as a whole, the population has been estimated at 300 000 to 400 000 persons (reference 2).

Virtually no services are available in any of the towns outside Bor and even there they are very limited.

Until 1981, the area was divided for administrative purposes into Provinces and Districts. Since that time administrative divisions have altered however, for convenience, the terms used in this paper are based on the pre-1981 divisions. From the point of view of water supply for human population, the districts of interest are Bor, Kongor, Ayod, Fangak and Waat with administrative centres at towns of the same name, except in the case of Fangak whose centre is New Fangak. All these districts lie to the east side of the river Bahr el Jebel and south of the rivers Nile and Sobat.

There are relatively few roads or vehicle access tracks in the area (Figure 2) and none are hard surfaced. Many of the tracks are difficult to traverse in a vehicle in the dry season and virtually impossible in the wet season. The main north-south road constructed largely on the canal embankment, from the mouth of the river Sobat in the north to Bor where it junctions with the road to Juba will, when complete, be passable in all months of the year excepting spells of particularly wet weather. A small number of other feeder roads recently constructed in the south of the area should also remain passable throughout the year.

2. EXISTING WATER SUPPLY PRACTICES AND PROBLEMS

2.1 HISTORICAL DEVELOPMENT

Domestic and livestock water supplies are obtained from rivers, swamps and river or rainfilled pools supplemented by water from open wells, boreholes and a small number of deep storage tanks or hafirs.

Open wells in the Jonglei area may be divided into those which draw on the shallow sub-alluvial aquifers and those which penetrate the deep permanent aquifer. Little is known about the history of shallow open wells. The development of deep groundwater resources only began in the late 1930s when the administration of the time initiated the construction of deep lined open wells. This work continued until the mid 1950s when the period of civil strife intervened.

Between 1960 and 1970 a small number of boreholes with diesel driven pumps were developed at important administrative centres.

In the ten years following the period of civil strife (1972 to 1982) the number of additional motor operated boreholes increased more than fourfold with units being located at both main and secondary administrative centres.

A hand pump installation programme was started in 1981 and a number of those units had been installed and in operation by mid-1982.

A small number of deep hafirs have been constructed in recent years largely as an indirect result of road or other construction works in the area.

At the present time natural sources of water supply, predominantly pools, still provide the majority of the water needs of the majority of the people and their livestock.

2.2 REVIEW OF EXISTING SUPPLIES

Water supplies for human consumption can be divided into those which are obtained direct from undeveloped sources (rivers, pools) and those which are obtained from sources which have been developed by man.

Only man made supply systems comprising boreholes, deep lined wells and deep machine excavated tanks or hafirs are considered here. Shallow wells which are excavated by traditional methods have limited scope for further development and are thus not considered further.

BOREHOLES

Boreholes are generally between 70 and 140m deep and are lined for their full depth. The pumps used are of three types, motor driven reciprocating motor driven rotary and hand operated reciprocating.

All the units installed up to 1972 use slow speed diesel engines to drive reciprocating positive displacement pumps and incorporate a lifting frame located immediately over the borehole. The motor driven units installed on or after 1972 use high speed diesel engines and positive displacement rotary pumps.

The hand pumps installed up to mid-1982 are lever arm positive displacement units (India Mk II). Since that date a number of flywheel type units have been installed; initial data on their operation suggests that they are more suited than the lever arm type even though they involve greater effort.

The number and status of the various borehole abstraction systems in the Jonglei area in early 1982 is given in Table 1.

Many of the motor driven pump units are currently not operational as a result of fairly simple faults, that is loose or missing base plate bolts, worn bearings or piston washers. In certain cases, borehole screens have apparently become choked leading to a severe reduction or total loss of flow at the pump. Where equipment is operational, fuel shortages severely restrict the amount of water which can be pumped.

It is noticeable that the (older) reciprocating motor driven units appear less prone to failure than the rotary units. This is probably due to their slow operating speed and very heavy solid construction, both of which minimise the effects of vibration on bolted connections and wear on moving parts. A third factor is the existence of an in-situ lifting frame which allows maintenance work to be carried out when required, without the need for special transport arrangements.

The rotary pump units presently in use appear to operate satisfactorily where operation and maintenance are of a reasonable standard.

The distribution of water from the motor operated pumps is in general rather unsatisfactory from a health point of view. From the pumphead water is frequently discharged either direct to the consumers's container or to a metal trough from which the consumers bail water to individual containers.

Excess water drains to a hollow in the ground from which livestock may be watered. A very small number of units are fitted with storage tanks and standpipes, however a programme is currently underway to construct elevated storage tanks and standpipes to operate in conjunction with the existing motorised borehole pumps.

A further problem related to construction is that of borehole pollution; in several cases it was found that waste lubricating oil from the diesel engine had accidently drained into the borehole; a problem which may be readily avoided by carrying the casing a short distance above the top of the concrete borehole surround.

The hand operated reciprocal motion pumps have had a very short period of operation so far. Nonetheless, a number of weaknesses have come to light. It has been reported that shock loading transmitted from the pump handle has encouraged the connecting rods to unscrew themselves; in addition the high pump usage combined with an operation stroke (used by the local people) much shorter than the design stroke has resulted in increased wear on certain parts of the mechanism (reference 3). Both the Rural Water Development Department and various church aid organisations operating in other areas of southern Sudan have reported very high wear rates resulting in regular attention by maintenance and repair staff being necessary. At present (1982) the hand pumps are being maintained by an external aid agency as there are not enough trained personnel to carry out this work.

The hand pumps are all provided with a concrete surround which drains excess water to a distant sump.

DEEP LINED WELLS

Deep lined wells are constructed of brickwork and have an internal diameter of approximately 1m. Depths range from approximately 20m to 53m.

A number of wells have a simple overhead windlass for lifting a large container, but for the most part these have fallen into disrepair and water is abstracted by individuals lowering their own small (3 to 5 litre) containers down the well on ropes and emptying the water into larger containers for transport to the home or for watering livestock.

Most of the wells surveyed are superficially in good condition but a number of wells were dry, or nearly so. It is probable that natural accumulation of debris in the wells over a number of years combined with damage caused during the period of civil strife has affected a number of them. A summary of the status and numbers of wells surveyed is given in Table 2.

Some of the wells were said by the local people to be polluted and the number indicated in the last column of Table 2 relates to comments by local people rather than to analytical data. Chemical analysis of water samples showed a small number of the well waters to have a high concentration of dissolved salts.

Wells which formed the main source of water were seen to be in continuous use from before dawn till after dusk during the dry season.

HAFIRS

Hafirs comprise either borrow pits modified for water storage purposes or purpose built water storage tanks with a depth of approximately 5.5m and a capacity of around 13,000m^3.

By the end of 1982 dry season some 11 deep hafirs (depth greater than 2m) had been constructed in the Jonglei area. All hafirs are unlined.

The main problems associated with hafirs are those of siltation and pollution, both people and livestock entering the water to obtain their requirements.

2.3 OPERATION AND MAINTENANCE

The day to day operation of water supply systems is the responsibility of the rural or district councils, the former dealing with the rural (out of town) areas while the latter are responsible for in town matters. Staff to supervise the operation of motorised borehole systems should be supplied jointly by the appropriate council and the Rural Water Development Department. The Rural Water Development Department should also supply fuel, spare parts and a maintenance and repair service. Workshops for major repair should be available in the district towns while minor repairs should be carried out in the field by mobile maintenance teams operating from the district towns. Experience of working with one of the mobile maintenance teams indicates that they are skilled and knowledgeable in the work they are responsible for.

In practice, chronic shortages of fuel mean that pumped water supplies are unreliable at the best of times. A shortage of skilled pump operating personnel leads to simple faults going unrecognised till failure occurs. Shortage of transport (and fuel) combined with poor access makes it impossible to provide adequate repair services and pumps may be out of action for long periods due to minor breakdowns. Lack of minor spare parts often prevents repairs being effected even when personnel and transport are available.

When relatively simple repairs to the above ground parts of a system have to be carried out, it is theoretically possible for maintenance staff to find their way to the site with the necessary tools using existing private transport facilities. Where the problem lies in the pump or screens, special transport facilities are required for bulky lifting equipment unless it forms an integral part of the unit.

Up to early 1982, maintenance and repair services for hand pumps were provided by the consultants responsible for pump installation however training of community based local supervisors equipped to carry out routine repair and maintenance work is now underway.

It has been found that local people prefer to provide a pump supervisor from within their own number rather than pay the government to provide this service.

Prior to the mid 1950s it is understood that maintenance of lined open wells was organised by the administration of the time. In recent years, some assistance in renovating open wells is understood to have been given by the government, however, there is no systematic maintenance programme and this work presently relies on the initiative of local people. It was found that the cleaning and maintenance of open wells had been carried out by local people in several locations in the past few years.

At present no systematic maintenance of hafirs is carried out. In the past local storage pools were occasionally cleared out by local people but his practice appears to have ceased. Recent trials have indicated that while it may be possible to restart such work, the effort involved in desilting deep hafirs is too great to be carried out manually using local labour.

2.4 TARIFFS AND THEIR EFFECT

Funding of day to day operations is paid for in part by direct charging for water at the motor operated boreholes. The supply of fuel and spare parts along with the cost of maintenance and repair work is paid for by the government with a subsidy from local councils fixed at 10% of the revenue collected from water sales.

Traditionally, water has been sold direct from the borehole and charges have been set for both domestic and livestock consumption. The present charge (1982) is US $0.02 per 20 litre can of water.

From limited field observations it appears that this clean source of water is used only when absolutely necessary, probably as a result of water charges and the unreliability of pumped supplies. In the wet season, in particular surface water of lower quality may be used in preference.

It has been noted in other areas of Sudan that people are generally not prepared to increase their travel distance to obtain water of a higher quality (reference 4) and this may be a further factor which limits the use of pumped supplies.

Where water is in short supply and people are forced to go to boreholes, the collection of water has at times been seen to be very disorganised and it is probable water charges cannot always be collected in full. It would thus appear that direct charging for water is not an effective way of funding operation and maintenance work and may have a negative influence on the health of people.

2.5 IMPLICATIONS FOR DEVELOPMENT

The main points which may be drawn from the field investigations are;

i) Water supply systems for use in remote locations, such as are found over much of the Jonglei area, must be capable of being operated and maintained for long periods by relatively unskilled personnel without external assistance or supplies, particularly fuel supplies.

ii) A pre-requisite for the provision of a water supply must be a sound, adequately funded operation and maintenance organisation with a training programme to back it up. The operation and maintenance of supply systems should be supervised by trained personnel.

iii) The accessibility of the water supply system from the maintenance and repair services base dictates the complexity of the water supply system which can be considered practical.

iv) The provision of new water supply systems, however basic, must be accompanied by health education if the full benefits of providing cleaner water are to be achieved. In this context, attention must be paid at the design stage to ensuring that water is not polluted during the supply process.

From the point of view of health, groundwater should generally be used in preference to surface water because of its inherantly better quality. Due to the ready availability of surface water for half the year, and the lack of suitable groundwater in certain areas, surface water is likely to continue to be an important source of supply for some time to come. The provision of a simple water treatment system to improve the quality of surface waters must therefore form part of any water development programme.

Considering the diseases which are common in the Southern Sudan (reference 5), the basic water quality criteria proposed for simple water treatment systems are virtual elimination of the vectors of Bilharzia and Guinea Worm and a significant reduction of bacteria and suspended matter. These criteria can be achieved by means of a simple sand filter (reference 6).

Where practical, higher standards should be set, bearing in mind that the setting of unrealistic standards and consistent failure to achieve them will most likely result in loss of faith in and eventual abandonment of the system.

3. A NEW APPROACH

3.1 METHODS OF SUPPLY

No one technical solution is appropriate to water supply over the whole of the Jonglei area. Which solution is suitable is determined according to the available water resources the ease of access and availability of maintenance services, and the level of demand for water.

RESOURCE CRITERIA

Where suitable groundwater is available, development may be carried out using deep lined wells or boreholes with hand or motor operated pumps. In areas where groundwater is unsuitable, surface water will be obtained from rivers or hafirs, or from the Jonglei canal when complete. Surface water will, however, be used in all areas for some time to come regardless of the availability of groundwater.

To avoid pollution of waters by people entering the source to obtain their requirements, pumped or open well abstraction systems should be constructed to operate in conjunction with surface water sources; in addition, sources should be fenced to keep livestock away.

To reduce the concentration of pollutants before use in the household, the raw water should be passed through a simple sand filter. Both proprietary (reference 7) and locally manufactured units are on trial on Sudan and suitable systems selected from those on trial may be used for either community or household applications.

ACCESS AND MAINTENANCE CRITERIA

For maintenance purposes, occasional vehicular access will be required to the site of all water facilities; the more complex the system, the more frequent the visits and the higher the standard of access road required.

The level of maintenance services available will be directly related to the access conditions. Maintenance and repair centres are based in the district towns and can give continuous cover to supply systems in the immediate vicinity, thus it should be possible to operate and maintain motor driven pumps in these locations. Motor pump systems will require all year round access roads to ensure continuity of fuel supplies in addition to any requirements for spare parts or specialist repairs.

Outside the district towns, the availability of such services will decrease with distance from the town and main road, indicating the use of simpler manually operated supply systems.

Hand pumps should, in the long term, require a lower level of attention than motor pumps and external assistance should in general be limited to routine inspection and major repair work. For this purpose the minimum requirements are a good dry season access road. To construct roads directly to all water points would be costly and not justified by the limited usage.

It has therefore been proposed (reference 8) that such roads should give access to within a maximum of 10 kilometres of hand pump equipped boreholes in rural areas. Where necessary, access tracks (up to 10km long) would be maintained from the main road to the water point as part of the supply system routine maintenance programme.

In locations where it is not practical to provide and maintain a road within 10 kilometres of a water point, supply systems, such as open wells or hafirs, which will not fail under conditions of minimal maintenance are required. Mechanical equipment forming part of such systems should as far as possible be man portable so that defective units may be carried to the main roads or to repair centres.

WATER DEMAND CRITERIA

Where water is not piped direct to dwellings, water consumption rates are greatly affected by the travel distance (reference 9). Within district towns, which will tend to become focii of development, relatively high population densities, short travel distances and the needs of development related activities will result in relatively high demands. Given a maximum travel distance of 500m, a unit rate of 40 litres per person per day is considered appropriate.

The very dispersed nature of the population within the rural areas means that for economic reasons water cannot be provided near to all dwellings and travel distances will be considerably greater than in towns. A maximum travel distances of 4km, reducing with subsequent development of 2km, has been proposed (reference 8).

In rural areas the water will be entirely for domestic use, except in the dry season when the human population of the permanent settlement areas will be reduced and some of the water formerly for domestic use will be consumed by livestock. As a result of these factors average consumption rates of 10 rising to 20 litres per person per day are considered appropriate.

The Jonglei area may thus be divided into districts towns requiring flexible high output systems and permanent settlements in rural areas requiring medium to low output systems.

Based on the factors considered above, water supply systems appropriate to the various areas and situations in the Jonglei area are given to Table 3.

3.2 OPERATION AND MAINTENANCE

The guiding principle in developing the strategy of operation, maintenance and repair, is that of an independent capability at community level, with back up services provided at district and provincial level through the Rural Water Development Department.

It is proposed that locally elected persons be given the necessary basic training and equipment to supervise day to day operations and carry out minor maintenance and repair work. They would be unpaid by the government; the local community should be responsible for electing these people and for rewarding them for the responsibility.

Major routine servicing and checking of equipment, the collection of water samples and a limited amount of emergency repair work would be carried out by mobile teams working from district maintenance centres. Mobile teams would inspect and overhaul all systems in their area at least once per 12 month period. Major repair work and the provision and distribution of spares and fuel will be the other main function of district maintenance centres. The periodic desilting of deep hafirs would be carried out by machine on a contract basis.

One mobile team (comprising three men) is proposed per district or per 100 water points (maximum). The mobile team will be equipped with all necessary tools and equipment and spare parts for dismantling pump systems and carrying out emergency repairs. Each team will have a four-wheel drive pick-up truck.

Each district will have a maintenance and repair centre capable of stripping and repairing pumps and engines and maintaining vehicles. District maintenance centres may also be used as a temporary base for periodic training programme for field operators and supervisors.

The provincial centre (in Bor) will be responsible for the overall supervision of the operation and maintenance organisation; the provision of administrative back-up services to the districts, including the distribution of wages and salaries; the co-ordination of the supply of goods and specialist technical services from outside sources. In addition, laboratory and training facilities will be provided at the provincial centre.

Both during the development and subsequent operating stage, there will be a continuous need for training of field operators and supervisors. This will comprise initial instruction, refresher courses and upgrading courses.

3.3 COST AND COST RECOVERY

Operation, maintenance and repair is essentially a district based activity and the basic cost of setting up a district centre will not be greatly affected by the type and number of water points. The recurrent costs will, on the other hand, be related to the numbers, the degree of complexity and the accessibility of the water points.

The estimated capital cost of providing and equipping a typical district maintenance and repair centre including local operation and maintenance staff is given in Table 4. These costs are based on the use of borehole and handpump systems except in the district town where boreholes with motor driven pumps would be used.

Indicative annual costs for a single district centre are given in Table 5. The estimate of staff salaries contained therein is based on the assumption that local (community based) operation and maintenance personnel are provided and remunerated by the local community. All other staff including engine operators are salaried staff, to be paid by the government.

Annual vehicle travel distances can be expected to be of the order of 20 000 to 25 000km each during the initial period of operation, when frequent visits to water points will be necessary to assist with repairs and give advice and instruction to the local water point supervisory staff.

In Table 5 the indicative long term annual operation, maintenance and repair cost is estimated at US $74 500 for a total of 83 boreholes equipped with handpumps and six waterpoints supplied from two motor driven borehole pumps. The average recurrent cost per water point, including the cost of access track maintenance, is approximately US $800. If access track maintenance is excluded the cost is reduced to approximately US $500 per year.

Assuming each water supplies 800 people, and considering the operation and maintenance costs alone the annual cost of water per person is approximately US $1 where access track maintenance costs are included, or US $0.60 where they are not.

The present system of funding appears rather unsatisfactory and not well suited to the situation in the Jonglei area. Once water is made available to virtually all the inhabitants of the area, it is proposed that the running costs be recovered by means of a general water levy on all inhabitants of the area, rather than payments by the litre.

3.4 DEVELOPMENT STRATEGY

When planning and supervising the development of a new water supply network in a remote and relatively undeveloped location such as the Jonglei area, a primary consideration must be the achievement of a viable operation and maintenance organisation to take over the running of the system on completion.

Finance should be provided within the construction budget for development and long term support of the operation and maintenance organisation.

While the initial training of individuals may take a relatively short time, a substantial period of operating experience will probably be required before operatives will have sufficient competence and confidence to handle the range of problems normally met.

In addition to providing facilities and training technical staff, it will be necessary to develop the managerial side to ensure that resources are suitably deployed, that work is properly executed and that all necessary services, such as training programmes, are provided.

A training and support programme should run throughout the construction period and for at least two years beyond completion.

At the planning stage for each individual location, before construction is underway, operation of the systems should be discussed and agreed at community level, and future supervisory and maintenance personnel recruited. In addition to necessary formal classroom training future operatives should where possible be involved in the construction of facilities in their area, and in the installation of plant.

On completion of construction and of building up the operation and maintenance organisation, both the plant and the trained personnel will become the responsibility of the appropriate government department. Close co-operation with all the government organisations concerned is therefore essential to ensure that personnel are readily absorbed into the system, and that the management of the operation and maintenance organisation fits into the structure and operation of the existing government departments. Quantity rather than quality.

Table 1 Status of equipped boreholes in the Jonglei Area - April 1982 (reference 1)

Type of pump	No. installed	No. operational*
Motor driven reciprocating	9	8
Motor driven rotary	33	23
Hand operated (lever arm type only)	8	8
TOTAL	50	39

* Three of the motor driven rotary units are only just operational. The hand pumps have experienced a number of breakdowns but are being maintained in operational condition by an external aid organisation.

Table 2 Status of lined wells in Jonglei Area - April 1982 (reference 1)

No. of wells located	No. of dry wells	No. of wells used		No. of wells polluted
		Regularly	Occasionally	
37	7	17	9	4

Table 3 Water supply systems and areas (reference 3)

Areas to be supplied and conditions	Supply system	
	Groundwater zone	Surface water zone (river or hafir supply)
District centre, good year round access	Motorised borehole* pump, storage tank and standpipes**	Motorpump with sand filter, storage tank and standpipes**
Permanent settlement, good access within 10km	Hand operated borehole* pump	Handpump with sandfilter
Permanent settlement, poor access	Lined open well, bucket abstraction	Handpump with portable sandfilter

* All borehole pumps to incorporate in-situ lifting frames.

** For reasons of hygiene, where motor driven pumps are used (regardless of the water source) the water must be discharged to a storage tank prior to supply to consumers via standpipes.

Table 4 Estimated capital cost of district maintenance and repair facilities (reference 8)

Item	Cost US $
Workshop, offices and stores	25 500
Two pick-up trucks	35 500
Tools for local operation and maintenance personnel	12 000
Spare parts for five years operation* of water supply systems	16 500
	89 500

Cost base mid-1982. Exchange Rate US $ 1.00 = £Sudan 0.96

* Based on two boreholes with motor pumps and 83 hand operated borehole pumps.

Table 5 Indicative annual cost of operation, maintenance and repair services for a single district (reference 8)

Item	Cost US $	
Depreciation of building and equipment	2 600	3%
Vehicle operating costs including depreciation*	10 600	14
Spare parts, fuel and oil for pumps	8 600	12
Staff salaries	13 900	19
Access track maintenance	26 000	35
Miscellaneous	3 100	4
Sub total	64 800	
Provincial centre services at 15%	9 700	13
Total	74 500	100

Cost base mid-1982. Exchange rate US $ 1.00 = £Sudan 0.96

* Vehicle operating and depreciation costs are based on two pick-up trucks with an annual travel distance of 10 000 km per vehicle.

FIG. I. LOCATION PLAN

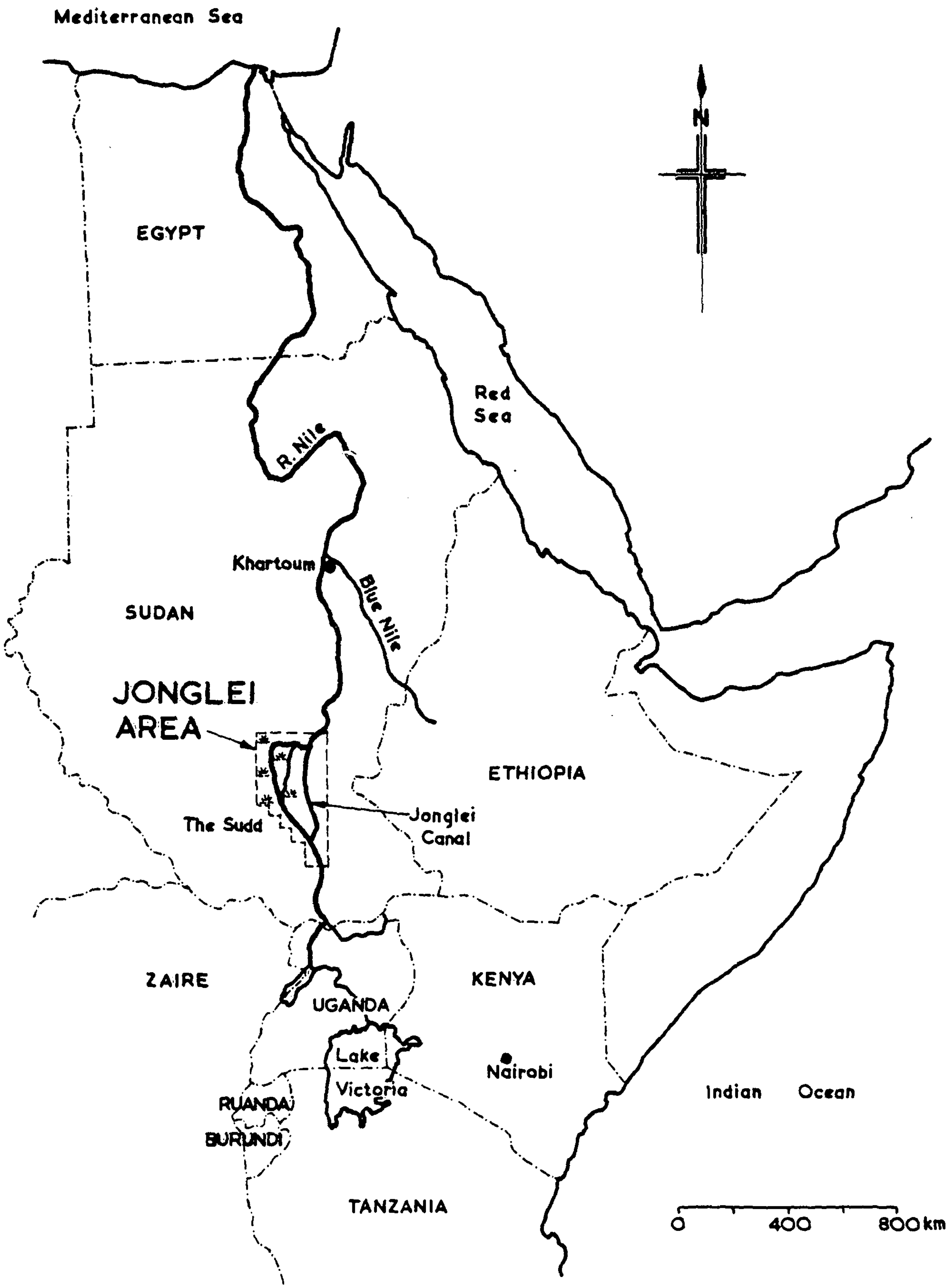
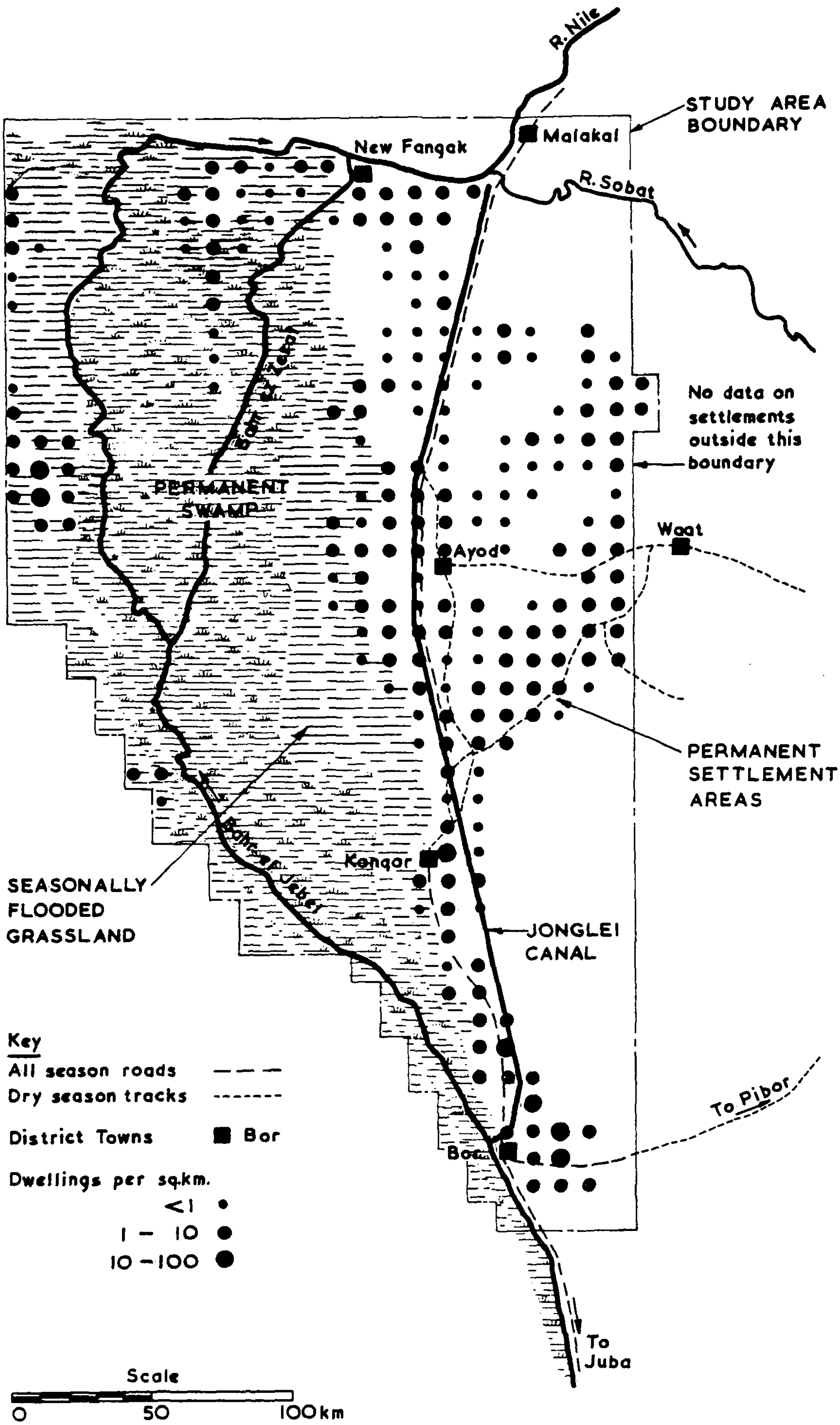


FIG. 2. MAP OF THE JONGLEI AREA



PAPER 6

THE ROLE OF UNICEF IN SUPPORT OF WATER AND ENVIRONMENTAL SANITATION PROGRAMMES IN EASTERN AFRICA

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1. UNICEF policy and practice regarding assistance to the water and environmental sanitation sector

In order to improve the welfare of mothers and children, UNICEF advocates and practically supports planning and implementation of programmes to improve child and maternal health and to educate children and their parents to be better able to cope with the many problems affecting their survival and development. Water supply, environmental sanitation, improved personal hygiene and safe storage of food and drink are all important components of preventive health care which in turn is a vital element of the primary health care strategy.

The time women save when water is made more accessible can help women to address their own families' needs better than the community's needs. It is UNICEF's aim to complement the actions of others supporting the International Drinking Water Supply and Sanitation Decade (such as governmental and non-governmental organizations, UNDP, the World Bank and WHO). Furthermore the aim is increased national, and local community level capacities to improve their water supply, environmental sanitation and hygienic conditions.

As the largest number of underserved people live in rural and peri-urban areas, UNICEF concentrates its resources in these areas.

Typical fields for UNICEF support in water programmes are:

Survey and programming (for UNICEF supported projects or for projects to be funded by government or international or bilateral aid).

Technical support to implementation of water, sanitation and health education programmes.

Training of staff, including in-service training.

Supply of equipment (drilling rigs, casing, pumps, pipes, or latrine construction materials).

Local manufacture of supplies (for example, handpumps). This can also involve support to technical co-operation between developing countries.

Promotion of community participation, especially the participation of women, in identification of needs and solutions, planning implementation, including the management, operation, and upkeep of facilities, establishment of repair and replacement systems, and full or partial contribution to the costs (in cash or kind), and training activities on the proper usage and upkeep of the water and sanitation installations.

Education in preventive health measures such as personal and food hygiene and training of community level workers to monitor the health condition and to promote preventive health measures.

Evaluative surveys of aided projects.

Preparation of national policies and plans and the need for close collaboration with all U.N. and other sources of external aid. This has been especially important in countries where UNICEF's involvement has been a significant element in large-scale national efforts.

In some projects, attempts have been made to link water and sanitation programmes with the issue of better nutrition. For example, in Malawi people have been encouraged to use the run-off from hand-pumped wells to irrigate small vegetable or fruit gardens. There is of course a close connection between water, sanitation and nutrition in that many of the diarrhoeal and parasitic diseases (which proper use of water and sanitation facilities can prevent) weaken people by interfering with their ability to absorb nutrients or prey directly upon their bodies. A possibility of collaboration exists that through food-for-work, labour-intensive water supply, sanitation or drainage projects can be implemented.

Efforts have increased in recent years to utilize water and sanitation workers to assist in promotion of health education especially regarding personal hygiene. Health education programmes have been given a big boost in recent years by evidence coming from around the world that a focus on a few relatively low cost preventive measures can achieve dramatic improvements in child welfare. In the UNICEF 1984 Report on The State of the World's Children, the four simplest and cheapest preventive measures which poor communities could apply are given as follows:

(1) Oral rehydration therapy - a simple and inexpensive method of preventing or correcting the dehydration which is induced by diarrhoeal infections and which, with an estimated five million young victims a year, is the leading cause of child death in the modern world.

(2) Growth monitoring - the use of simple ten US cents child growth charts which, along with regular monthly weighing and back-up advice, can help parents to make better use of the food they have and prevent up to half of all the malnutrition in the developing world.

(3) Expanded immunization - using newly-improved vaccines to prevent the six main immunizable diseases from killing an estimated five million children a year and disabling five million more.

(4) The promotion of scientific knowledge about the advantages of breastfeeding and about how and when an infant should be given supplementary foods.

Many development projects have shown that increased community involvement can help lower initial installation costs but what is even more important is that it can result in better utilization of these facilities. Furthermore community involvement in maintenance is the best way of ensuring that this is done opportunely and at reasonable cost.

Even where community involvement is an integral part of project design, the importance of including women at all stages of the project is sometimes overlooked. As women are usually the drawers of water, it is in their interest to see that water projects which will ease their daily burdens and improve their families' well being are implemented successfully and that they are maintained properly.

Further, women can be facilitators for organizing community projects and for promoting good hygiene and sanitation practices. In the eastern Africa region another important reason for involving women in water projects is that one or more of the older male members of many families are absent due to one reason or another (often they are employed far from the rural areas in cities or in other countries).

Many women are interested in village level work and are likely to remain in the community for longer periods of service than their male counterparts and are therefore likely to be keen to be involved in community development projects. Another important reason to seek increased involvement of women is that over the past 20 years there has been a great increase in the number of women and girls completing primary and secondary school. Some of these may be interested to serve as water minders or handpump caretakers. Many of the problems in operating water supply or other village level services revolve around administration and management rather than purely technical problems and women can and should be encouraged to serve in these functions as well.

In practice, UNICEF has tended to concentrate on spring protection and well construction as opposed to treated surface water and to depend more on handpumps than on those powered by diesel or petrol. The reasons for this are that surface sources often dry up in times of drought and small rural communities cannot generally afford to pay skilled operators to run treatment plants nor are they able to readily obtain the necessary chemicals. While most protected springs and wells have been found to give water of satisfactory bacteriological quality, in at least two types of situations the danger of polluted source increases.

One such situation is that which prevails when a very large number of people depend on a single well, spring or tap stand. This increased the chance that the tap, pump or the source itself will be polluted either by direct handling, use of polluted priming water, or infiltration from a dirty environment around the water point. If the number of people depending on the water source can be kept to 200, or better still 100, the risk of pollution is much less than if 1,000 or more people use the source.

point sources

Furthermore, a smaller group can organize itself more easily to look after the well and to discipline those who might through ignorance or carelessness tend to abuse the facility. Another risky situation occurs where the source is very shallow ground water. In Malawi and elsewhere efforts are being made to improve the protection of such wells; however, when all else fails such water may have to be treated to ensure bacteriological safety.

In several countries UNICEF is attempting to achieve standardisation of handpump components which are locally produced. This has the double advantage of simplifying the stocking of spare parts and of allowing local procurement which can be replicated by government or other local parties. In eastern Africa, Uganda, Malawi and Zimbabwe they are working along these lines; these principles have also been applied on a larger scale in Bangladesh and in India. It is of course necessary to include funds for training and for the establishment of quality control procedures.

In many groundwater development projects it has been found that despite the many difficulties in water well construction these are eventually overcome. What is generally needed is more attention to the design of the water well to prevent pollution and to avoid the entrance of sand and grit which will damage the pump. Another common pitfall is that which occurs when the water well digging and well drilling run far ahead of the pump installation. Timely and good quality installation work raises public enthusiasm and prepares the way for an economical maintenance system. Involving some of the people who have been selected as future caretakers in the pump installation work is one way to get a head start on training for maintenance.

In Ethiopia there has been some collaboration between UNICEF and FAO in installing protected springs in the same areas where soil erosion and watershed protection work is going on. In planning the preventive maintenance of water systems the protection of the watershed should not be ignored. In rural water systems one is often dealing with micro-watersheds. It would be helpful if scientific information on how best to protect such small watersheds in various climatic and soil conditions were made available.

The size and shape of protected areas above and around springs has to be fixed and, in eroded areas, new vegetation may have to be planted. Some countries may also need advice on appropriate legal measures required to safeguard such water supplies.

2. Plans and commitments for eastern Africa

25-30%

On a global basis just over one quarter of UNICEF's assistance goes to the water and environmental sanitation sector; in the 19 countries covered by UNICEF eastern Africa region office, about one fifth of the commitments are to this sector (these countries are Botswana, Burundi, Comoros, Djibouti, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Rwanda, Seychelles, Somalia, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe). UNICEF water and sanitation commitments to these countries are currently of the order of ten million U.S. dollars per year and over half of this comes from special contributions above and beyond UNICEF's regular budget.

In approximate descending order of budget of this sector the 12 largest programmes are as follows: Ethiopia, Tanzania, Somalia, Uganda, Djibouti, Rwanda, Burundi, Zimbabwe, Mozambique, Botswana, Malawi and Lesotho. Commitments are usually made for several years (two to five years being typical) and the value of approved projects at any given moment is generally greater than the commitment because so many water and sanitation projects are depending on special contributions which must be sought once the project is approved.

About ten per cent of the sector budget is spent on sanitation and related promotion and education. This may often be done in the context of a primary health care or integrated basic services programme; however, water is often a component in the first phase with sanitation coming in later phase. The current commitments to sanitation are in Tanzania, Botswana, Lesotho, Zimbabwe, Somalia and Mozambique with some projects likely to come up in Ethiopia, Malawi and Rwanda.

The types of water supply projects assisted by UNICEF in eastern Africa include: protected springs and/or gravity feed piped systems (Burundi, Ethiopia, Rwanda and Uganda); a sub-surface dams (Ethiopia and Somalia); dug wells and handpumps (Ethiopia, Malawi, Somalia, Uganda and Zimbabwe, rain water catchment (Burundi, Comoros and Kenya); drilled wells with either hand or power pumps (Djibouti, Ethiopia, Malawi, Tanzania and Uganda); piped schemes with diesel or electric pumps (Mozambique and Tanzania).

3. Water consumption and related behaviour

In order to find ways of improving health benefits of water and environmental sanitation programmes, UNICEF has a small project which has started field work in Kenya and hopes to start work in Botswana, Ethiopia and Tanzania in the near future. This project is funded by SIDA. After studying and analysing health related behaviour of people in areas where some improved water systems have been installed, it will test various ways of educating people to adopt improved practices to protect their health.

As has been found in many countries, the taste of water is very important to people and even slight differences in taste may require considerable time before they are acceptable. Thus chlorinated water is generally objectionable and those used to drinking turbid water may even feel that it tastes better than clear water. In areas where there are plenty of springs people naturally get used to and prefer clear water but may be quite unaware that the clarity of the water does not guarantee absence of pathogens.

In some areas the impact of previous health education programmes are seen in people's knowledge of various ways to protect their health; however, this does not mean they practise what they know. For example in some homes visited people rushed shamefacedly to cover drinking water containers as they had been taught that this was better. Nevertheless the general home environment in such areas, where previous health education efforts have been made, is probably cleaner than would otherwise have been the case.

In dry nomadic areas water consumption is as low as one tenth of the 40 litres per capita per day which is often recommended as a good quantity for use in drinking, cooking,personal and domestic hygiene. Many people wash water containers at the source but, if many people have to wait in a queue for a small amount of water, they may skip the washing of the container in order to save time and water.

Obtaining data regarding sanitation and toilet habits is much more difficult as in most cases people are generally hesitant to discuss such matters. Clearly most people do not wash hands after elimination and, aside from the necessary behavioural change, soap is often lacking.

Future plans call for testing a broad range of information and educational techniques including: traditional story tellers, meetings of local leaders, calenders and posters, illustrated lesson material for schools and for adult literacy classes and women's groups. Songs and slogans will also be tried.

The traditional cultures have stressed certain rules. However, with increased population densities and other changes affecting rural life, new rules (modern taboos) will be needed to break the multiple disease transmission pathways which endanger the life and health of the people. Individual changes may be possible; however, when entire communities can decide together to take up environmental projects and adopt improved hygienic behaviour, individual good intentions can be reinforced by group decisions and some of the necessary work may be done in such a way as to provide an element of social fun.

4. Guidelines for design

UNICEF has assisted with developing materials for some of its assisted projects and various other rural water supply projects which UNICEF has encountered have produced useful materials. For ground water projects the Manual for Integrated Projects for Rural Groundwater Supply produced in Malawi by the Government, ODA and the U.N. is one such useful document. The India Mark II Handpump Installation and Maintenance Manual may also be of use to those planning handpump projects.

For those interested in piped gravity feed supplies the design criteria developed with the assistance of Prof. P. Khanna of the Indian Institute of Technology in Bombay might be useful. The guidelines for operation and preventive maintenance of the Mueda Plateau water system in Mozambique (prepared by Dr. J. Christmans of UNICEF) may be useful for those taking up similar projects.

Several publications have come out of the work on gravity feed systems including a recent book titled Village Water Supply in the Decade by Colin Glennie (currently of UNICEF Kathmandu). There are also UNICEF publications on many of the subject areas in the above discussion of policy and practice.

5. Summary of problems and solutions from positive experiences

Many maintenance problems stem from lack of proper investigation, design and attention to quality installations. By increasing attention to these matters and using standardized locally produced components the chances of success are improved. Training and equipping village level caretakers and making sure that spare parts are available is the next step. An example of this is the UNICEF assisted Bangladesh handpump programme where between 80 and 90 per cent of the pumps are generally in functioning order and where almost all the problems can be attended to by village level workers. Having a good service level (only 100 to 150 people per handpump) may also be a factor in the relative success of this project.

Administrative problems are often worse if the local government is not involved and empowered to take action on water supply and sanitation matters. Local government authorities are better able to draw out community enthusiasm than centralized purely technical agencies. When handpump caretakers (as in Bangladesh) or fontainiers (as in Burundi) are employed by the local government authorities communication and speedy action are enhanced.

If time is spent to pick up local knowledge and beliefs about health, water, sanitation and related behaviours during project preparation, the plans can be made more effective. The problem of new or strange tasting water may pass with time, but in areas of highly mineralized water and no good alternative sources, treatment may be unavoidable (more research and practical testing is needed on village level water treatment).

The policies and practices discussed above have grown out of experience from many projects. Long term continuity of programme is needed as many desired changes cannot be brought about overnight. Involvement of the public and education and training of people participating in the project concerning the important issues (health, environmental, technical, administrative, operational, management and funding matters) will help to identify and solve problems and generate support for the sustained efforts needed to maintain beneficial service systems.

India 6-7 years local manufacture of India Mk II pump established.
Target new rigs drilling 100-150 wells / year
17 years experience

TABLE 7

TURNKEY PROJECTS - AN ALTERNATIVE METHOD OF IMPLEMENTATION

BY

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1. INTRODUCTION

In recent years concern has been expressed to an increasing extent about the time involved in executing urban water supply and sewerage projects if the procedure considered normal by the development banks are followed. These procedures involve the following steps:

- Project identification
- Technical and economic feasibility study
- Project appraisal by development bank
- Loan agreement
- Detailed design and tender documents
- Contracts for procurement and construction
- Commissioning

Additional refinements include sometimes the prequalification of tenderers - and prequalifications and competitive tendering for consulting services, sometimes for the separate stages of study, design and supervision. Depending upon the individual circumstances, the overall implementation period can vary between five and 10 years. This time span is often inappropriate to the urgent requirements of the community which is suffering from an inadequate water supply, or sanitation system, and of the authority which has an obligation to that community to improve the position.

Turnkey procedures are now being employed to an increasing extent to overcome this situation; they have also been used in an endeavour to overcome the difficulties of some borrowers in drawing down a loan facility and utilising the resources available to them. Following a prequalification procedure, tenders are invited from approved contractors or joint ventures who must assume responsibility for detailed design, procurement of all materials and equipment, construction and installation, and commissioning - possibly with a requirement for operation and personnel training over an appropriate period. Turnkey tenders are normally invited against a tender document which establishes the basic concept of the project, mandatory requirements and standards - together with drawings illustrating the concept and other essential information.

Turnkey tenders must be accompanied by outline designs and descriptions in sufficient detail to indicate clearly what is being offered, and to permit an adequate technical and financial evaluation. Since the owner is obliged to compare offers involving different materials and plant, the tender must be accompanied by sufficient detail to facilitate a present-value comparison of the bids. For this reason, details concerning energy consumption and the like must be supported by appropriate guarantee clauses in a contract agreement.

The traditional and turnkey procedures are well illustrated by reference to two projects which proceeded simultaneously in Jordan (Figure 1) recently:

1. Aquaba Water Supply: the Qa Disi Project (for the Water Supply Corporation, WSC).
2. Amman Water Supply: the Azraq Project (for the Amman Water and Sewerage Authority, AWSA).

In addition, the turnkey procedure is currently being employed in an interesting project in the Yemen Arab Republic (Figure 1) which is being funded in part of the World Bank/International Development Association.

3. Sana's Sewage Treatment Plant, Stage I (for the National Water and Sewerage Authority, NWSA).

The author's firm has been the consulting engineer in all three projects, and has fulfilled roles in the turnkey projects (Amman and Sana's) which differ markedly from the traditional duties (Aqaba) - where they worked in association with Arabtech Consulting Engineers.

2. JORDAN

2.1 AQABA WATER SUPPLY: THE QA DISI PROJECT

Aqaba is located strategically on Jordan's only seaboard, on the Gulf of Aqaba in the Red Sea. Following reopening of the Suez Canal, the past decade has seen rapid growth in the port facilities, the free trade zone, and in industry, commerce and tourism. In August 1976, Howard Humphreys was asked by the Overseas Development Administration (ODA) to report to the National Planning Council on a technical and economic feasibility study of the best means for improving the (then) inadequate supply. At that time, the population was about 18,000 and up to 2 Mm^3/a could be obtained from boreholes in Wadi Yutm.

Following further hydrogeolical studies, the feasibility study report (July 1977) was submitted; the most cost-effective solution was the construction of a wellfield and headworks at Qa Disi, a transmission pipeline with break pressure tanks to a terminal reservoir at Aqaba, a transmission pipeline direct to the south coast industrial zone and a new distribution system in the town. A further report on preliminary engineering designs and on economic and financial studies of the project was prepared in November 1977, and this confirmed the main components of the project (Figure 2). Detailed designs and tender documents were started at that time, while the government reached agreement with the following agencies for assistance with funding:

Saudi Fund for Development
Arab Fund for Social and Economic Development
Overseas Development Administation.

It was agreed that the project would be carried out under seven contracts, and details of each contract - which were awarded between October 1978 and April 1979 - together with the respective contract sums are set out in Table 1.

Water was delivered to Aqaba in October 1981, in order to meet the commissioning date for the new fertiliser factory, and a Certificate of Completion for the main civil contract No. 5 issued in January 1982. The outstanding works were completed in June 1982, although the final payments to be made under that contract have still to be determined.

Figure 3 shows the overall implementation programme in bar-chart form, and relates to a scheme designed to deliver and distribute 10 Mm^3/a (317 l/s) - with a final output of 17.5 Mm^3/a (555 l/s).

2.2. AMMAN WATER SUPPLY: THE AZRAQ PROJECT

Amman, the capital city of Jordan, experienced severe water shortages during 1978 and 1979. At that time, the population was about 800,000 and supplies were derived mainly from boreholes in the city area. Various alternatives for augmenting the supply had been identified within a report on North Jordan Water Use Strategy in 1977, but only one scheme, the Azraq project, offered an easily exploited source. Accordingly the government agreed that the Amman Water and Sewerage Authority (AWSA) should invite tenders for the work on a turnkey basis from a short-list of six contractors who had prequalified for another water supply project earlier in 1979.

During the post-war years many studies had been made of the desert oasis of Azraq, which is located some 100 kms ESE of Amman; it had been concluded that between 10 and 15 Mm^3/year (317 to 475 l/s) could be extracted safely from the pools.

The sequence of events between the decision to proceed and the award of a turnkey contract can be summarised as follow:

<u>1979</u>

1 August	Tender document to six selected contractors, due for return on 1 September. Offers invited from selected consulting engineering firms for services in tender evaluation, contract negotiation and supervision of construction.
19 August	Agreement for consulting services signed.
1 September	Four tenders received and evaluation started; detailed discussions with all tenderers, with responses to formal questions recorded on a questionnaire. All tenderers put forward alternative proposals together with their response to the scheme outlined in the tender document.
25 September	Evaluation completed and report submitted recommending an award.
26 September	Negotiations started with recommended contractor.
9 October	Negotiations completed. Contract terms and sums agreed.
14 October	Contract agreement signed, with formal starting date 28 October 1979 - and completion within 304 days (28 August 1980).
11 December	Amendment Addendum No. 1 signed regarding terms of payment and Letters of Credit.

The evaluation phase involved a very close liaison between the consulting engineer's specialist team and the authority's representatives. The work involved identifying the degree to which the offer conformed with the requirements of the tender document, and a careful technical appraisal of each component within the original offer and within the tenderer's alternative proposals. Confirmation was obtained from all named suppliers of plant and materials that they could meet the delivery dates quoted in each tender.

The negotiation stage concentrated on determining those areas where the contractor's proposals required modification to be acceptable on engineering grounds, and how the necessary improvements could be obtained and at what cost. The discussions resulted in agreement on the following essential documents:

Schematic plan showing the essential features of the work as agreed.

Revised outline specification and design parameters

Conditions of Contract, based on FIDIC 3rd Edition 1977

Bar-chart construction programme

Contract Sum, split into six packages.

The Azraq project is shown in outline in Figure 4 and details of the agreed work packages are set out in Table 2 together with the respective contract sums. The extent of the contract was increased as the work progressed, and details of the respective variation orders are included also in Table 2.

The Letters of Credit were actually opened on 20 December 1979, some 21 days later than the date specified in the tender. For this reason, the completion time was increased to 325 days, and the completion date established as 17 September 1980. The contract provided for liquidated damages for late completion set at JD 10,000/day up to a maximum of 10% of the contract sum; similarly a bonus for early completion was established at JD 5000/day up to JD 300,000 maximum.

By January 1980, general designs of the pumping station, generating station complex (Package 3) had been agreed and site work started; detailed specifications for all imported materials had been agreed and orders placed. The contractor's mobilisation was completed in February and 44 kms of pipeline delivered. Pipelaying started in April 1980, by which time most of the detailed designs had been approved and further materials delivered to site. Good progress continued until water was first passed to Amman on 25 September, and the engineer provided a Certificate of Substantial Completion on 27 September 1980.

Factors leading to the successful and timely construction of this major project capable of delivering 10.9 Mm^3/a (350 l/s) to Amman, including a 600 mm diameter transmission pipeline 102 km long, can be summarised as follows:

A skilled contractor's team working a seven-day, 84 hour week

Close teamwork and co-operation between the representatives of the authority, the contractor and the consulting engineer - resulting in potential problems being foreseen and overcome.

2.3 COMPARISON - AQABA AND AMMAN PROJECTS

The principal events in both contracts are shown in bar-chart form in Figure 3, and the comparison of the two projects involving similar work contents is striking. Discounting the previous studies which identified both projects in general terms, the times to issue of the respective Certificates of Substantial Completion were as follows:

Aqaba: the Qa Disi Project .. 5 years 4 months

Amman: the Azraq Project .. 1 year 2 months.

It is apparent that the Azraq project was not examined in the same depth as the Aqaba scheme in order to identify the most cost-effective solution. Moreover, there were no supporting economic and financial studies to determine if the Azraq project would meet the constraints normally imposed by the development banks. Nevertheless, the project satisfied the principal criteria established by the government - that Amman should not suffer further water shortgates on the 1978/79 scale, and that works should be completed within the minimum possible time by selective competitive tendering to utilise fully the Azraq oasis source for that purpose.

The normal duties of the consulting engineer, as exemplified in the Aqaba project, were curtailed and compressed to meet the challenge of the turnkey approach at Azraq. Concentrated specialist services during intensive periods of evaluation and negotiation were complemented by urgent action during the construction period in reviewing and agreeing equipment specifications and detailed designs - and in quickly resolving changes imposed by site conditions as found. Total fees for consulting services in the two projects amounted to some 6% (Aqaba) and 2% (Amman) of the total contract sums in Tables 1 and 2. The difference reflects the omission of studies at Azraq, and the much shorter construction period.

2.4 FURTHER EXTENSION OF THE AZRAQ PROJECT

In order to extend further the use of the facilities built in 1980, the authority AWSA negotiated two further turnkey contracts with the same contractor:

a) Equipping ten boreholes drilled by others into the basaltic aquifer near Azraq, and constructing 17 km of branch pipelines terminating at the main pumping station - together with electricity transmission lines to the wellheads, and an additional pump and two generators at the main power station.

b) Constructing a break pressure tank and booster pumping station some 55 kms from Ain Ghazal adjacent to the 600 mm transmission pipeline, with interconnections thereto.

These works (Figure 4) were constructed between April 1981 and December 1982, and increased the source and transmission capacity of the scheme by 52% from 10.9 Mm^3/a (350 l/s) to 16.6 Mm^3/a (525 l/s).

3. YEMEN ARAB REPUBLIC

3.1 SANA'S SEWAGE TREATMENT WORKS, STAGE 1

In 1976, Howard Humphreys submitted a project report on the sewerage and sewage treatment facilities recommended for Sana's, the capital of the republic. The report visualised a staged construction programme, Stage 1 providing for the sewerage of the older parts of the city which was projected to have a population of 108,000 in 1985 out of a total population of 192,000. It was recommended that sewage would be treated on a 125 ha. site on the city outskirts, the process involving waste stabilisation with mechanical aeration followed by facultative ponds and maturation ponds. The site could house extensions adequate to serve a population estimated at 262,000 in the year 2000.

The report was accepted by the National Water and Sewerage Authority (NWSA), and detailed designs and tender documents prepared for the work; it was intended that separate contracts would be let for the procurement of pipes, covers, fittings and the treatment plant equipment - and for the construction of the sewers and treatment works. Contracts were duly awarded (with the assistance of the World Bank/IDA) for the procurement of all materials and equipment, and deliveries to Sana's were completed in 1982. However, funding difficulties delayed the award of a contract for construction of the sewerage system until March 1983, and this work will be completed in 1986.

Meanwhile the authority could no longer secure the use of the treatment works site owing to the rapid growth of Sana's and pressure to commit the land to other purposes. Outline designs were prepared for another site some 6 kms farther from the city (Figure 5) - the area still being adequate for waste stabilisation ponds and suiting a gravity outfall sewer without resort to pumping. Resistance from local communities obliged the authority to return to a part of the original site - where only some 36 ha. could be used now for the treatment facilities. This area was considered inadequate for waste stabilisation ponds and it proved necessary to consider another process.

In view of the past delays and the urgency of proceeding with the project, NWSA accepted a World Bank/IDA proposal in September 1983 that tenders should be invited from prequalified contractors on a turnkey basis. The prequalification stage and the special tender documents are described in the following paragraphs.

3.2 PREQUALIFICATION STAGE

By international advertisement, experienced contractors from World Bank member countries, Switzerland and Taiwan were invited to prequalify by completing a detailed questionnaire. The notice indicated that the Stage 1 plant would serve an equivalent population of 150,000 that tenderers could utilise any particular process or design, and that the final effluent should be suitable for irrigation and/or aquifer recharge.

The questionnaire provided an outline description of the proposed tender document and of the sewage and final effluent characteristics would be specified. Full details were demanded of the contractor's financial status and of his recent and current experience of similar projects. In the case of joint ventures, such information had to be entered for each member firm together with a copy of a formal agreement between the parties concerned.

Prequalification questionnaires were supplied on request to 233 companies, and 95 copies completed and returned by the end of the stipulated two-month period. Evaluation followed in accordance with World Bank guidelines, and on assessment procedure was agreed with the Bank and NWSA which weighted the following factors:

- Previous experience of similar work on a turnkey basis
- Ability and experience of treatment plant design team
- Previous experience of working in the Middle East or YAR
- Financial background
- Ability to provide satisfactory plant, personnel and organisation
- Ability to complete the works on time
- Present workload.

On this basis, a short-list of contractors was agreed from whom tenders would be sought.

3.3 TENDER DOCUMENTS

The document stated that the treatment works contract would provide for the design, construction, training and operation (for two years in the first instance) of a plant having acceptable facilities for sewage and sludge treatment. Other required facilities included:

- Standby electricity generation
- Disinfection of treated effluent
- Storage of treated effluent to permit conveyance off-site by tanker
- Irrigating a tree-belt around the Stage 1 works, together with surplus land on the site reserved for future stages
- Test percolation basins on the surplus lands.

Works design parameters were set out for Stage 1 and Stage 2 flows, sewage and final effluent quality - in terms of BOD and suspended solids - and for preliminary, primary, secondary and sludge treatment by any process. Details were provided also of the requirements for standby generation, chlorination, site works, site irrigation and percolation basin tests, and of the allowances to be made for training, operation and maintenance.

The tender document emphasised the importance to be placed upon the incorporation - as far as possible in obtaining the most cost-effective solution - of treatment plant equipment already procured by NWSA for the original waste stabilisation pond design and now stored in Sana's. The equipment was fully described and would be provided free of charge to tenderers wishing to incorporate it in whole or in part.

Other particulars included a topographical survey of the site, trial pit logs and an assessment of the engineering geology.

The tenderer was invited to offer a fixed sum in an accepted international currency plus Yemeni Rials, coupled with a maximum period to substantial completion of two years, and a two year maintenance period. A feature was that tenderers were obliged to include a present value cost analysis which would reflect the costs of the initial investment and subsequent costs in renewal, operation and maintenance over a period of 40 years at full design flow.

Prices would be expressed at 1984 levels and discounted at a rate of 10% per annum, guidance being provided on renewal intervals and the costs of labour and maintenance. Guarantees had to be provide of the maximum annual energy consumption and the annual haulage of dewatered sludge (as used in the present value cost analysis).

Tender documents were sent to the prequalified firms in December 1983, with a closing date for submission set in March 1984.

4. CONCLUSIONS

The turnkey approach to project implementation offers advantages in the construction of urgently required water supply and sanitation facilities. Competent contractors, possibly in association with equipment and materials suppliers, are equipped to respond satisfactorily to tender invitations which set out clearly the basic requirements and standards, the conditions of tender and contract, and the terms of payment. If this basis is not established, tender evaluation is extremely difficult and a contract award subject to lengthy negotiation to establish necessary variations to the original offer which are acceptable to both parties. Where different processes may be offered, the tender should be obliged to submit a detailed present-value cost analysis founded on criteria laid down in the tender document.

Both the traditional and turnkey approaches require the prior and clear identification of the project to be made by the owner - possibly with his consulting engineer. The extent and content of the project identification study clearly depends on the particular circumstances, and upon the policy of the agencies concerned with funding the works.

The engineer has a different but vital role in the turnkey projects - first in the prequalification stage but primarily in establishing a tender document which sets out the essential requirements while leaving the contractor freedom in proposing technology in which he has particular competence. The engineer's role continues in applying his judgement in tender evaluation, and thereafter in agreeing the contractor's detailed designs and particulars within the framework of the contract. A secondary role for consulting engineers lies in assisting contractors with the outline designs and quantities essential to the tendering stage, and thereafter assisting with the required detailed designs.

Table 1 Aqaba Water Supply Project: Contract Schedule

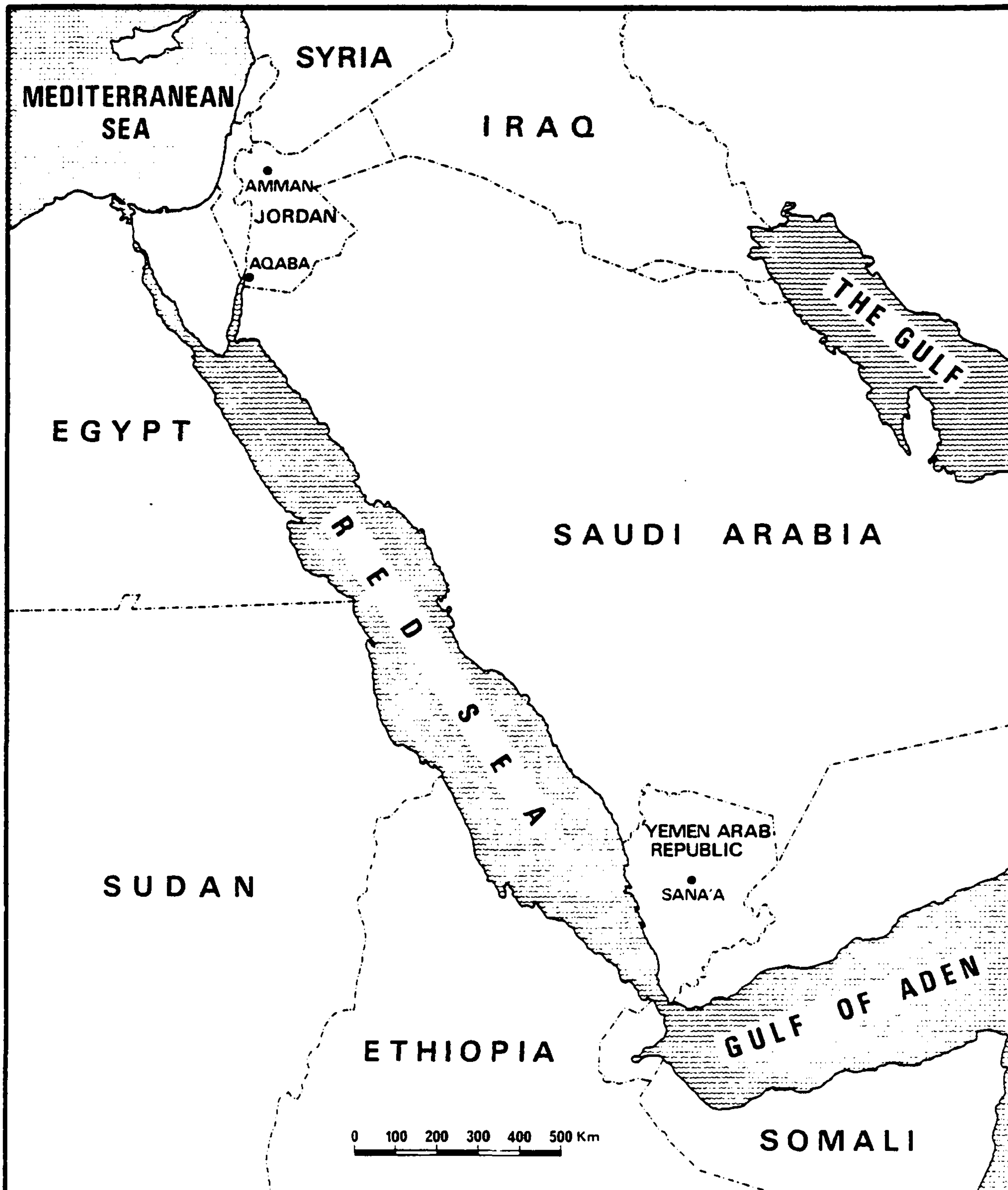
Contract Ref.	Type	Description	Contract Sums JDm	(US $m) approx.
1A	Procurement	Ductile iron pipes: 80/800 mm	2.771	
1B	Procurement	Ductile iron pipes: 700 mm	0.738	
3	Procurement	Borehole pumpint equipment	0.275	
4	Procurement	Generating equipment	0.662	
6	Procurement	Valves	0.111	
		sub-total	4.557	(12.30)
2	Construction	Boreholes: 7 production 2 exploratory 1 observation	1.366	
5	Construction	Transmission pipeline (92 kms 700 mm), head-works (inc 19km wellfield mains), reservoir	4.555	
7	Construction	distribution system (mains 26 km, 2 service reservoirs)	0.504	
		sub-total	6.425	(17.35)
		Total	10.982	(29.65)

(Note: based on assumed exchange rate JD 1.00 = US $ 2.70)

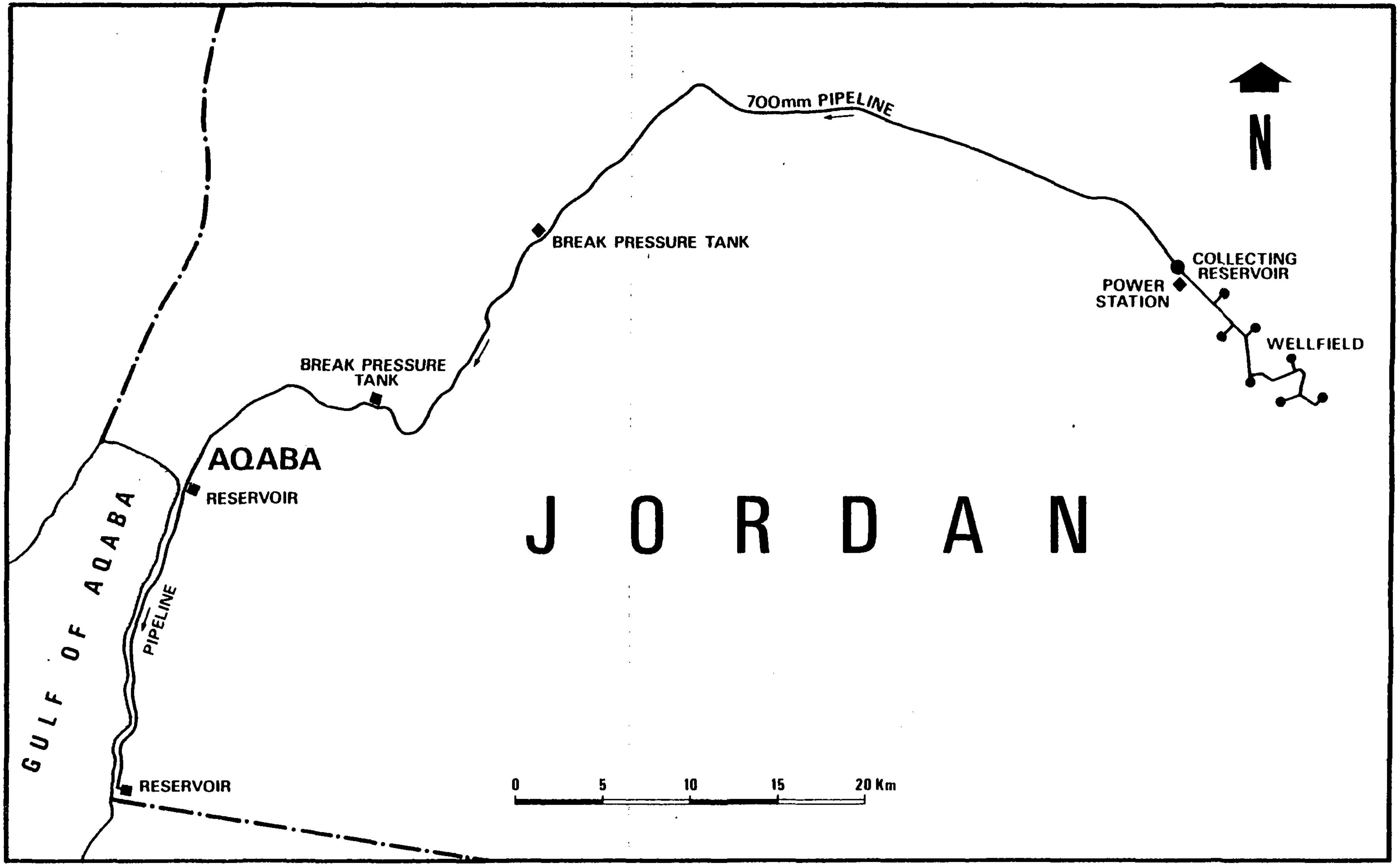
Table 2 Amman Water Supply Project: Schedule of Work Packages

Work Package Ref.	Description	Contract Sums JDm	(US $m) approx.
1	Intake pumping stations at Druze and Shishan, and 250 mm 6km pipeline between.	0.471	
2	5000 m³ steel reservoir inc. valves and pipework, and chlorine dosing equipment	0.104	
3	Main pumping station, complete with all pumping equipment.	0.546	
4	Main power house complete with four 880 kW diesel generator sets and power lines	0.832	
5	Administrative complex including all buildings, roads, fencing and landscaping	0.410	
6	Transmission pipeline 102 km 600 m from intakes to main pumping station to Ain Ghazal in Amman	5.922	
	Sub-total	8.285	(22.37)
Variation Order Ref.			
2	Additional 2800 m³ reservoir	0.100	
3	Fuel transfer station	0.005	(0.28)
	Sub-total	0.105	(22.65)
	Total	8.390	

(Note: based on assumed exchange rate of JD 1.00 = US $ 2.70)



LOCATION MAP FIGURE 1



AQABA WATER SUPPLY : QA DISI PROJECT **FIGURE 2**

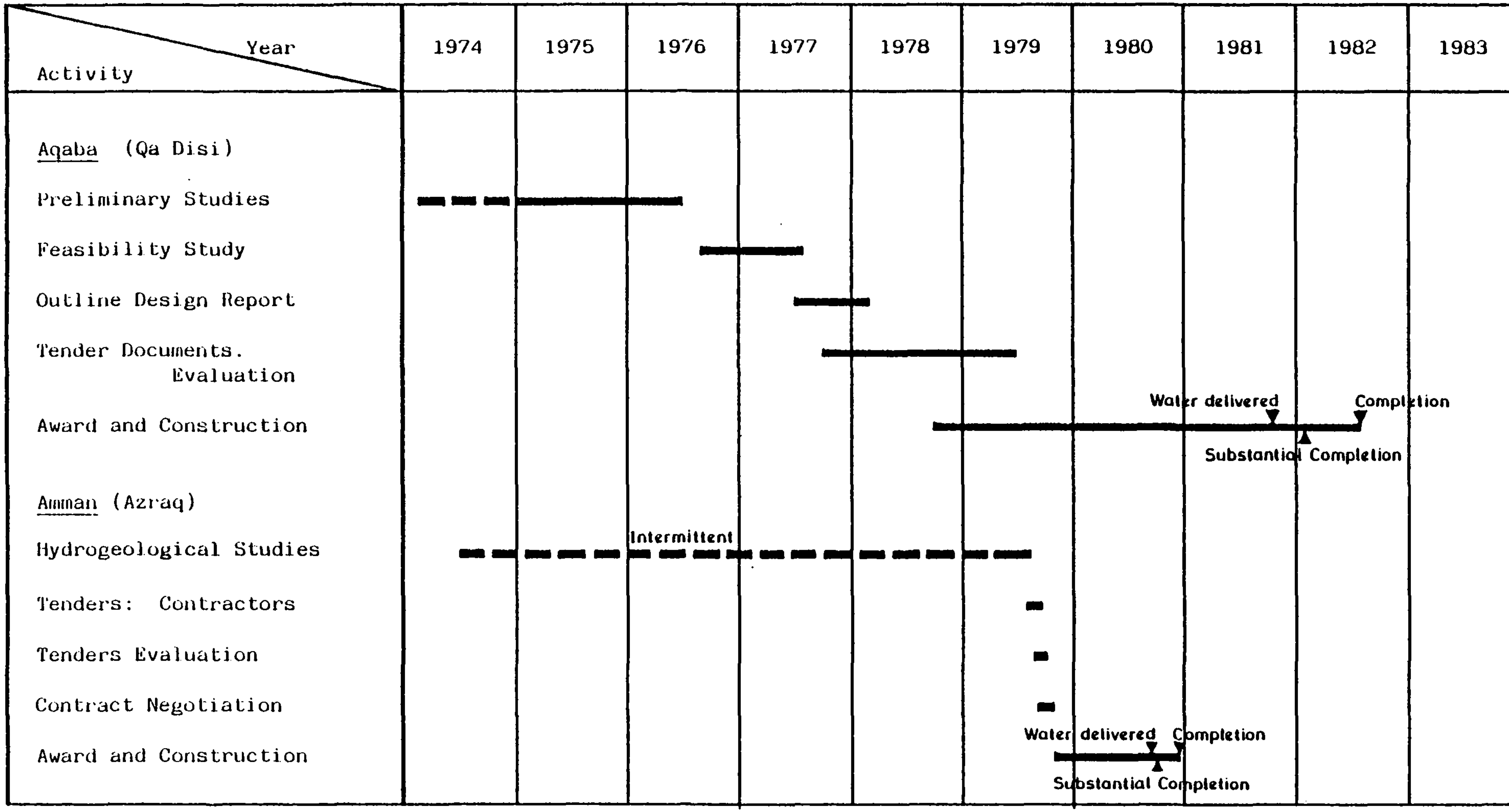
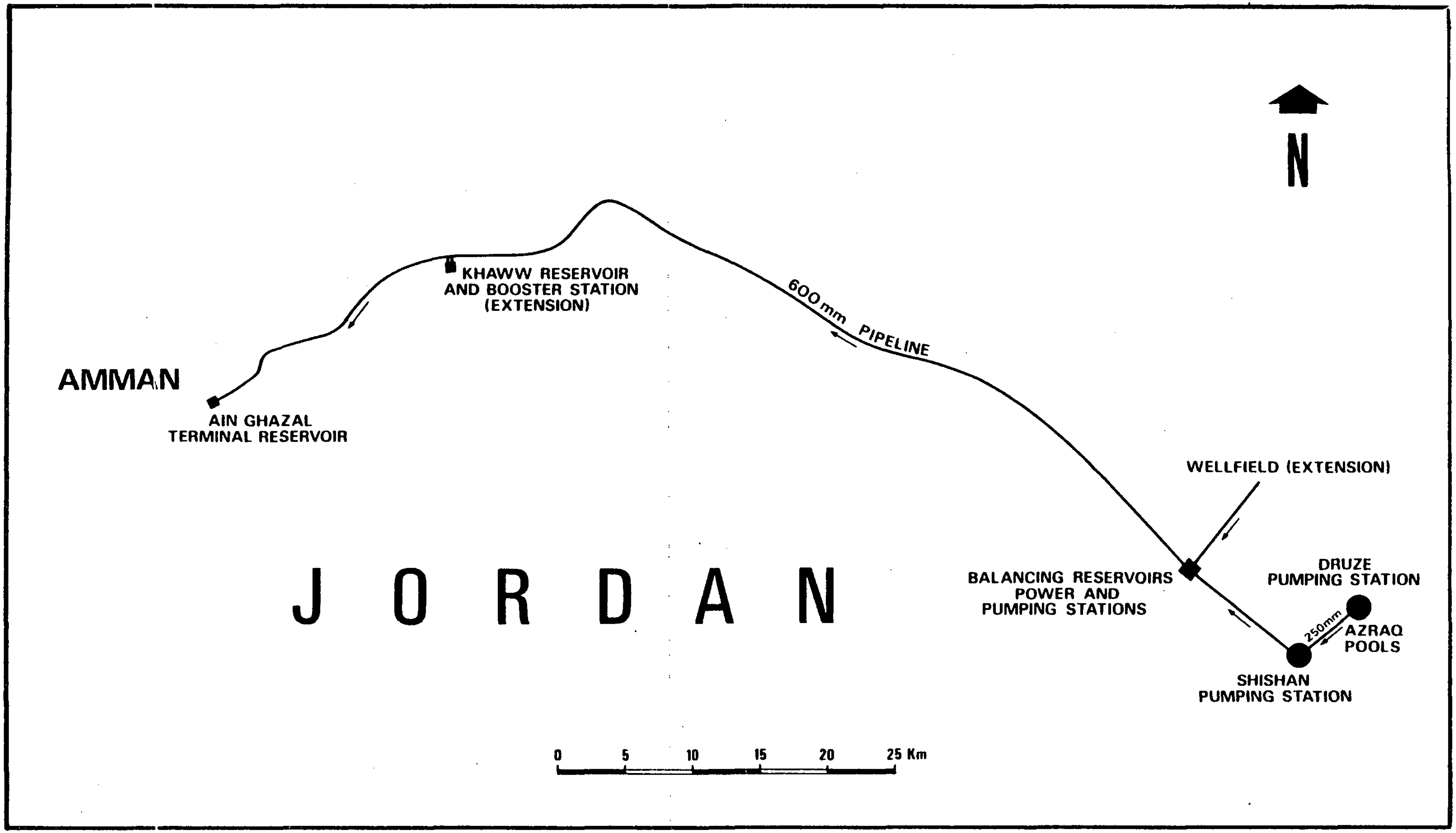


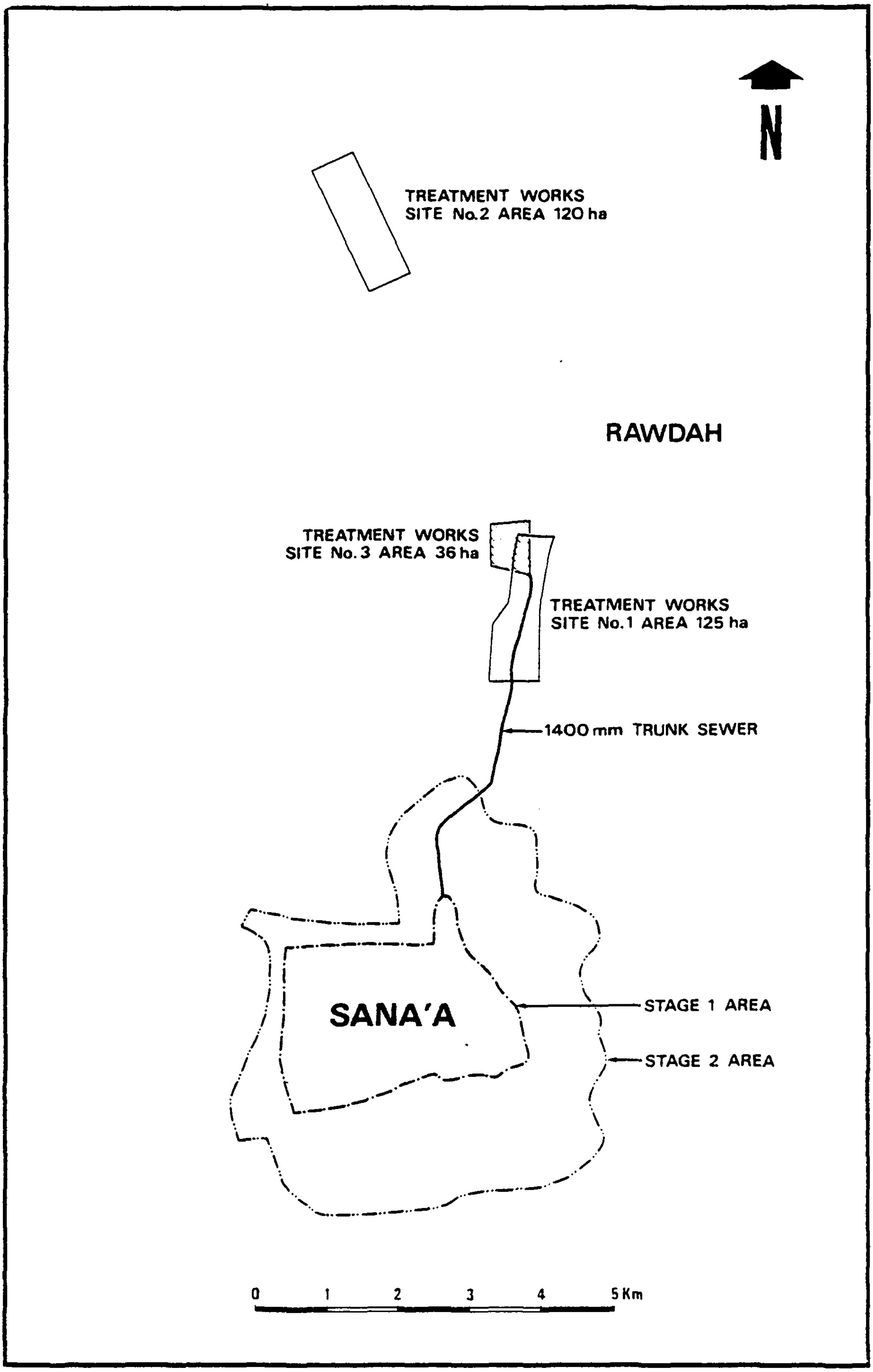
FIGURE 3 : COMPARISON OF IMPLEMENTATION PROGRAMMES



7.14

AMMAN WATER SUPPLY : AZRAQ PROJECT

FIGURE 4



SANA'A SEWAGE TREATMENT WORKS STAGE 1

FIGURE 5

PAPER 8

EMERGENCY WORKS FOR AUGMENTING EL HAWATA TOWN WATER SUPPLY SUDAN, 1982/83

BY

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SUDAN NATIONAL ADMINISTRATION FOR WATER

and

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SUMMARY

El Hawata in the Eastern Sudan is situated on the east bank of the Rahad River at the point where the railway line from Khartoum to the Eastern Region crosses the river. Some 20,000 people in the town and the surrounding countryside depend on the Rahad River at el Hawata for their water supply.

The river is seasonal and flows for about five months each year. For two-thirds of the year, water is taken direct from the river, and for one-third of the year from an off-river storage reservoir (hafir) which is filled annually when the river is in flood, initially by gravity and subsequently by pumping.

Apart from a very limited supply to tanker trucks, the stored water is then conserved for four or five months, and as long as there is residual water in the Rahad River channel. When this is exhausted, the stored water is made available, being collected by hand, by donkey cart or by tanker from the hafir.

This arrangement has worked satisfactorily since the hafir was constructed in 1971. In 1982 the Sudan Government started moving Ethiopian refugees from other locations in Eastern Sudan into a new settlement for 5,000 people near Hawata town. This necessitated putting in hand emergency works to avoid a serious shortage of water supplies during the latter half of the 1982/83 dry season. Design studies showed that by raising normal hafir storage level 1m, sufficient additional water could be stored to ensure a minimum supply for the refugees. The extraction of this extra water from the river would require additional pumping machinery.

Construction started in October 1982. This included repairs to the hafir embankments (which had never previously been subject to above ground storage) the installation of extra pumping equipment and piping (mainly supplied by the UN High Commissioner for Refugees), and the building of a substantial sudd (earth embankment) in the river to pond up receding flood water. Emergency pumping started in the middle of November and continued through December and into January 1983.

The paper briefly describes design calculations for this emergency scheme, with technical details of the works which were planned and carried out. It also records the organisations involved in the execution of this programme, with details of the methods of executing the various operations.

1. INTRODUCTION

1.1 BACKGROUND

The town of el Hawata lies in the Eastern Region of Sudan about 350km from Khartoum. It is situated on the east bank of the Rahad River at the point where the main railway line from Khartoum to the Eastern Region crosses the river (Figure 1).

Being at a river crossing and at the intersection of the railway line with road routes running adjacent to the river, el Hawata is important as a trading centre with a market, and as a watering point for travellers. The township area is shown in Figure 2.

The 1978 census gave the resident population of the town as 15,459. In 1982 the chief administrative officer at el Hawata estimated that the population which depended on the town's water supply system was about 20,000 which was further increased as the dry season advanced and people from outside the town came to el Hawata for water when their local sources dried up.

1.2 SOURCE OF WATER

The source of water for the town and surrounding area is the Rahad River, which rises in Ethiopia and flows seasonally for five to six months each year between June and November or early December, rising to a flood peak in August or September, as will be seen in Figure 3. When the river is flowing it is the source of water for all the people of el Hawata and the surrounding neighbourhood. During the dry season when there is no river flow, measures are taken to store surplus flood water by diverting river water into a 110,000m³ capacity hafir (earth storage reservoir) which is filled partly by gravity and partly by pumping.

2. EXISTING WATER SUPPLY SYSTEM

2.1 HISTORY

The first stage of the present water supply works for el Hawata, consisting of the hafir, intake works and river pumping station, were constructed by the Rural Water Corporation in 1971. Nearly half the cost of these works was met from funds collected from the local community through its town council. The council also undertook to be responsible for operation and maintenance, for which funds were provided by central government.

The RWC also provided a portable pumping unit for extracting water either from the river or from the hafir for collection by consumers. The river supply point, which is used when the river is flowing, is shown in Figure 2. In 1978 funds were raised locally to provide for a distribution system to the town area. RWC then constructed the pipe mains and water points, followed by a pumping station and elevated service tank near the hafir a year later.

2.2 EXISTING PERMANENT WORKS

Figure 4 is a plan of the existing hafir and intake works and Figure 5 shows a longitudinal section through the intake and outlet system. When the water level in the river is high and above the level of water in the hafir, water enters the intake structure, flowing through two 350mm diameter pipes into chamber No. 1 and then continues through the same size pipes to chamber No. 2 and on into the hafir (Figures 4 and 5).

When there is no longer sufficient head for gravity supply, water is drawn from the river by pumping from chamber No. 1 and delivering through two 150mm diameter pipes to the top of chamber No. 2. The gravity supply pipes from chamber No. 1 to chamber No. 2 are closed by valves and the pumped water then flows under gravity from chamber No. 2 into the hafir.

Pumping is usually maintained until the water level in the hafir is at original ground level and this storage (110,000m^3) is found to be sufficient to meet the normal needs of the community with some reserve at the end of the dry season.

The supply arrangements which were constructed consist of an outlet pipe (Figure 5) delivering to chamber No. 3 by gravity, with a pump or pumps for drawing water from chamber No. 3 and supplying either to the distribution trough for local collection or to the elevated storage tank for piped distribution to the township. For a number of technical reasons this supply system has not been used in recent years and the present arrangement consists of a portable pump on the inside edge of the hafir delivering to a pipe over the bank and into the distribution trough or direct into portable tanks.

2.3 OPERATION

Gravity filling usually starts in the middle of August each year and continues for about ten days. This is followed by pumping for two months to bring the water level in the hafir up to inside berm level, equivalent to ground level. Thus the hafir is filled by the end of October or early November before the river level drops below the intake structure.

A limited supply of water is provided throughout the year to certain official bodies such as the town council, the hospital and the government sawmill, using tractor-pulled tankers. The rest of the community obtains its water for 8½ months in the year from the river and for 3½ months from the hafir. Water is drawn from the river soon after it rises in July, when a portable pump is set up at the river extraction point (Figure 2). Water is collected from this point by a fleet of privately owned donkey carts, each with a capacity of 400 litres.

Each year in October or November, after the river has passed its flood peak, a sandbag embankment (or sudd) is constructed across the river just downstream of the hafir to pond water in the river bed and thereby prolong the river supply, which usually lasts until the end of February.

When the river supply is exhausted all consumers are then permitted to collect water from the hafir, water being pumped over the hafir bank for this supply as already described.

3. WATER SUPPLIES FOR REFUGEES

3.1 REFUGEE SETTLEMENTS IN QALA EN NAHL AREA

The first influx of refugees from Ethiopia into the Eastern Sudan occurred in March 1967 when 20,000 people crossed the border near the town of Kassala. A few months later several thousand more sought asylum in Kassala Province. Further major influxes occurred in 1970, 1972 and 1975. In January 1980 the government estimated that Kassala Province provided asylum for approximately 250,000 refugees (reference 1).

The policy of the government has been to move the refugees away from border areas and into settlements with essential public services, where they can be assisted to become self-sufficient. In 1970 an area of 74,000 feddans (31,000 ha) was allocated for the use of refugees in Qala en Nahl rural council district about 40km south of Qala en Nahl town (Figure 1).

The first stage of this scheme consisted of the establishment of settlements in the vicinity of six villages in the area, namely Salmin, Um Saqata, Adingerar, Um Burush, Deheima and Zarzur. As water was not available locally, a water supply scheme was implemented by RWC and funded by the United Nations High Commissioner for Refugees (UNHCR) to bring water to the area from the Rahad River.

3.2. THE ABU NAHL WATER SUPPLY SCHEME

The scheme comprised the construction of two large hafirs of capacities 235,000m^3 and 172,000m^3 on the river bank at Abu Nahl, with a pumping station to supply water through a 34km steel main pipeline to four service hafirs. In 1976 this scheme was supplying water to about 15,000 people, of whom 13,300 were resettled refugees and 2,200 were local inhabitants (reference 2).

3.3 THE QALA EN NAHL / EL HAWATA PROJECT

In 1980 the government started planning for three more settlements in this area for a total of 15,000 refugees in the vicinity of the villages of Balos, Bia and Huweig. Again, water supplies were not available locally and an extension of the Abu Nahl scheme was initially considered.

However, investigations showed that the existing scheme could not supply an additional population of 15,000 to 20,000 people and it was therefore decided to provide water for the new settlements at Balos, Bia and Huweig from a hafir storage system and pumping station near el Hawata town which would also supply a fourth new settlement at el Hawata. This supply would be designed to meet the needs of 20,000 refugees and 5,000 local inhabitants.

The original planning and designs for this project were carried out by the technical staff of the Rural Water Corporation, now reorganised as the National Administration for Water (NAW) in 1980, and the layout of the project is shown in Figure 6. This scheme was designed on very similar lines to the Abu Nahl scheme with a combined gravity and pumping supply from the Rahad River to fill two storage hafirs, each of 250,000m^3 capacity, a high lift pumping station and a main pipeline for delivery to service hafirs within the settlement area.

The UNHCR agreed to assist with the implementation of this project and allocated funds for the detailed engineering surveys and designs, and for the procurement of equipment. To minimise delays the final designs were anticipated and the UNHCR placed orders for pumps, steel water tanks, and steel pipes and pipe fittings in June 1981. This equipment was delivered at the end of 1982 and early in 1983. Gifford and Partners were appointed by the UNHCR in July 1981 to provide technical assistance to this programme.

During the 1981/82 dry season the NAW carried out engineering surveys and investigations for the design of the hafirs, intake works and pumping station. In April 1982 tender documents were prepared for the first stage of construction, covering these works. The intention then was to make an immediate start on construction with a view to completion during the 1982/83 dry season.

In the meantime approaches by the government of Sudan to the Federal German Government led to an offer of German technical assistance on a fairly wide scale which would incorporate the Qala en Nahl/Hawata project. The immediate outcome of these developments was to bring the UNHCR assisted project to a standstill and this situation continued up to the end of 1982, with no alternative programme for water supplies for the new refugee settlements.

3.4 THE EMERGENCY

While refugees could not be moved to Balos, Bia or Huweig because there is no spare water at all in these areas for new settlers, settlement at el Hawata had already started by August 1982 on the basis of an assured water supply in the Rahad River for at least six months until about February 1983. The provision of water for the refugees at el Hawata after the Rahad River supply ceased early in 1983 thus became a matter of extreme urgency.

Attention was therefore directed to the existing el Hawata town water supply system with a view to increasing its capacity in order to provide for both the town community and the additional refugee population. Preliminary studies indicated that this could be achieved by increasing the hafir storage and adding additional pumping capacity.

To meet the immediate requirements of the refugees in 1983 it would be essential to complete the implementation of emergency work before the 1982 river flood had subsided. In September 1982 engineers were instructed to carry out field investigations and designs for these emergency works. By mid-October 1982 about 2,000 refugees had been settled at el Hawata and it was planned to increase this number to 4,000 by mid December, with a final total of 5,000 by the end of July 1983.

In view of the seasonal fall of the Rahad River in November it was very important that measures to abstract and store more water from the river flood should be treated as a matter of urgency. The town council of el Hawata agreed that if extra water could be pumped into the town hafir during November and December a supply for the refugees could be made available from the hafir during the normal supply period from March to July 1983, or until the river flow resumed. In order to ensure water for the refugees until March 1983 it was proposed, with the full agreement of the town council, to construct the temporary earth embankment due to be placed in the river in October or November, to a higher level than in previous years to provide additional ponded storage.

4. THE DESIGN OF THE EMERGENCY WORKS (reference 4)

4.1 WATER REQUIREMENTS

The estimated population to be supplied at el Hawata was 20,000 in 1982. As has been mentioned, some of those in official positions or working at official establishments are supplied with water by tanker from the hafir throughout the year. Allowing for 1,000 people to be supplied in this way, this means that some 19,000 people are drawing water from the river for seven months of the year from the beginning of August to the end of February and from the hafir for five months from the beginning of March to the end of July. Between August and November the supply from the river is from flowing water and from December to February it is from ponded water.

Taking a daily per capita consumption of 26 litres for the local communities, the first part of Table 1 shows estimated total requirements for the population of 20,000 people for the three periods of the year when the river is flowing, ponded and dry.

The lower part of Table 1 gives the equivalent figures with 5,000 refugees added to the local population of 20,000 using the standard emergency supply rate for refugees at 15 litres per capita per day. Thus it was estimated that to provide for the additional refugee population the ponded storage in the river would have to provide a further 7,000m³ during the three months December to February, and the hafir would then have to provide a further 11,500m³ between March and July 1983.

The figures in Table 1 refer to human water consumption only and some provision would also have to be made for animal watering. There were no statistics available on the number of animals watered at el Hawata, but it was clear that the river was constantly being used for watering animals and that when the river dries up completely animals need to be provided with water from the hafir. Provision therefore for animal watering would have to be made at between 50 and 100m³ per day.

4.2 RIVER STORAGE

During previous years the sudd at el Hawata was usually built to pond the river water to a maximum depth of 1.25m and this produced a storage 13.6km long. The volume stored at this level was estimated to be approximately 170,000m³.

The usual practice was for this construction to be completed by the end of November and this stored water was used during the three months December, January and February. Using Piche evaporation records for Gedaref and a factor 0.5 to give open water evaporation, the evaporation loss from the river storage for these three months was calculated as 110,000m³.

Thus the available water for domestic and animal consumption out of a gross storage of 170,000m³ would be 60,000m³. Referring to Table 1, the estimated requirements for human consumption for these three months was 44,460m³. Adding to this a further 10,000m³ for watering animals and other purposes brings the total to 54,460m³, out of an available 60,000m³, which confirms that the estimated figures were of the right order of magnitude.

Referring again to Table 1 the estimated requirements for human consumption including 5,000 refugees during the three months December to February is 51,210m³, and with animals and other uses the total would be 61,210m³. It is thus evident that with the refugees it would be necessary to increase the ponded storage in the river.

It was therefore decided to construct the sudd to a height of 2.25m producing a reservoir approximately 19km long with a gross storage of about 665,000m³. Evaporation from this larger reservoir during the same three months was calculated as 220,000m³, leaving a nett volume of 445,000m³ for domestic and animal consumption. This extra storage was very considerably in excess of the amount required to provide for the additional refugee population but it was necessary to raise the storage level to a sufficient height to ensure that the water ponded back to within easy reach of the refugee settlement. The larger reservoir also helped to alleviate the town council's concern that after the poor rains of 1982 many people from surrounding areas might tend to migrate to the el Hawata area later in the dry season of 1983 in search of water.

4.3 HAFIR STORAGE

The normal practice for operating the hafir was to fill the storage to berm level by 1 November and to conserve the stored water until 1 March when it was then made freely available to all consumers. Under this arrangement there was enough water for el Hawata town and neighbourhood for five months from March until the end of July, by which time water was flowing again in the Rahad River. Figure 7 shows the relationships between the depth of water in the hafir, its active volume and water surface area. When filled to berm level the water level is at 10.51m above the invert level of the hafir outlet. At this level the stored volume is 120,000m³.

Under the emergency arrangement it was planned to raise the storage by 1m with further pumping, increasing the stored volume to 151,500m³. As will be seen from Figure 7, this extra metre, spreading the water over the berms, would increase the surface area by over 100%, thereby causing a large increase in the evaporation losses for the first three months. Apart from the tanker supplies, the storage in the hafir would be conserved as in previous years until 1 March 1983, after which date and for the next five months the stored water would provide for the el Hawata community and the refugee settlement.

Calculations showed that this arrangement would be feasible on the basis of a supply of 26 litres per head per day for the normal el Hawata population and an emergency minimum supply of 15 litres per head per day for the refugees. The estimated water consumption was calculated month by month on this basis (and the quantities are summarised in Table 1).

The total evaporation during the seven months of storage from January to July was estimated as 1.615m. Monthly quantities of water lost to evaporation were obtained by multiplying the mean water surface area each month by the monthly evaporation. In addition to the evaporation loss it was assumed that there would also be a seepage loss and this was taken as 60mm per month multiplied by the mean water surface area for each month.

The storage calculations for the seven months from January to July 1983 are summarised in Table 2. Starting with the storage of 151,500m³ on 1 January 1983, the calculations showed that this storage would meet the requirements up to the end of July with some in reserve carried over into August, by which time the Rahad River would be flowing again.

4.4 PUMPING CAPACITY

Under the normal filling operation gravity filling started at the beginning of August and extended for about ten days, followed by pumping for about two months to bring the storage to berm level by mid-October. The quantity of water pumped during these two months including evaporation losses, and consumption amounted to 35,000m³ or an average of 583m³/day.

Under the emergency arrangement it was planned to raise the water level in the hafir 1m above berm level as quickly as possible. Because of the increasing head and the considerably increased surface area and volume per unit of rise above berm level, additional pumping capacity would be needed. If the final storage level could be achieved in a further two months it would be necessary to pump at a rate of 1,500 to 2,000m³/day for this period. It was therefore decided to install three additional temporary pumps which could be obtained from stocks held by the UNHCR in Sudan. The pumps selected for this purpose were G3/LT1 Godwin/Lister 75mm pump units. Operating these for 13 to 14 hours a day it was possible to deliver about 1,800m³ to the hafir daily.

5. IMPLEMENTATION OF THE EMERGENCY WORKS

5.1 ORGANISATION

Planning of the emergency works was carried out in conjunction with the National Administration for Water, the Rural Water Corporation, Gedaref, the Commissioner of Refugees Office, the Hawata town council and UNHCR. Diesel pumps and piping were provided from stocks held by UNHCR at Hawata. The emergency works were implemented through the Commissioner of Refugees Project Manager at el Hawata. This included negotiating contracts with local contractors for repairs to the hafir banks, for consulting the temporary embankments in the Rahad River, and for providing labour for the installation of pumping machinery and piping.

On 28 October 1982 Rural Water Corporation engineers inspected the hafir and confirmed that several erosion gullies on the inside slopes of its banks should be filled. Subject to the satisfactory completion of these repairs they authorised the filling of the hafir to 1m above berm level. This decision was subsequently confirmed by the RWC Kassala provincial engineer.

5.2 REPAIRS TO THE HAFIR

The repairs to the hafir banks were carried out by a local contractor. Work started on 4 November 1982 and was completed by 5 December 1982 which included the excavation, placing and compaction of 247m³ of earth to fill erosion gullies on the inside banks.

5.3 CONSTRUCTION OF THE SUDD

In conjunction with the COR Project Manager's office at el Hawata a contract was made with another local contractor to construct a mini-barrage of sudd in the Rahad River using hessian sacks filled with earth dug from the river bank, supported where necessary by wooden stakes driven into the bed. Three 6.3m long pipes made from open-ended oil drums welded together were built into the sudd to carry the river flow during construction. The pipes were provided by the town. A total of 10,000 sacks were used in the works.

Work started on 11 November 1982 and was completed by 3 December 1982 when the sudd had been constructed to an approximate height of 2.3m above river bed level in midstream and flow through all three pipes had been stopped.

5.4 TEMPORARY PUMPING INSTALLATION

The arrangements for the emergency works are shown in Figure 8. The three Godwin/Lister G3/LT1 diesel pumpsets were taken from storage in el Hawata and installed at the hafir intake site. Steel pipe, 75mm diameter, was used on the suction side of the pumps and 75mm diameter flexible hose was used to connect the delivery to a 150mm diameter steel pipeline 86m long which was laid to discharge into chamber No. 2 near the hafir. Pumping started on 19 November 1982 and continued daily. By 10 December 1982 the pumps had been operating for 288 hours and the water level in the hafir had risen 0.67m. The combined discharge of the three pumps as measured on 5 December 1982 was 26 l/sec or 130m³/hr.

5.5 FILLING OPERATIONS

The normal filling of the hafir to berm level (10.510m on Figure 7) was completed by mid-October, but it was over a month before the additional emergency filling started on 19 November 1982. During this period, the water level in the hafir fell to 10.410, representing a loss of storage of 5,500m³, of which about 2,000m³ was due to tanker supplies from the hafir and 3,500m³ to evaporation.

By the end of November, with the extra pumping, the water level had been brought up to berm level. During this filling, a large quantity of water was taken up in wetting the berm and banks and the recently-placed bank repair works. It was estimated that about 18,000m³ were absorbed in this way. Figure 9 shows the observed and forecast levels in the hafir and the Rahad River from August 1982 to July 1983.

COSTS

The total cost of constructing these emergency works was LS10,257 excluding the cost of the diesel pumping units and piping provided by UNHCR. A breakdown of these costs is given in Table 3.

The cost of operating the emergency works for one month from mid-November to mid-December was LS685, which covered wages for a pump attendant and guard, diesel fuel and lubricants.

6. ACKNOWLEDGEMENTS

Some of the data and information incorporated in this paper has been obtained from the Sudan National Administration for Water, the Sudan Commissioner of Refugees and the United Nations High Commissioner for Refugees, and the authors record their acknowledgement of these respective sources of information. The design studies for the emergency supplies were carried out by Gifford and Partners. The cost of the emergency works was met from funds provided by UNHCR and administered by the Sudan Commissioner of Refugees and the works were executed through the office of the Commissioner of Refugees at el Hawata and the el Hawata town council.

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Table 1 Estimated water requirements at el Hawata

Quantities in m^2

Period	State of river	From river	From hafir	Total
WITHOUT REFUGEES				
August-November	Flowing	60,270	6,960	67,230
December-February	Ponded	44,460	5,135	49,595
March-July	Dry	-	84,460	84,460
Year		104,730	96,555	201,285
WITH REFUGEES				
August-November	Flowing	69,420	6,960	76,380
December-February	Ponded	51,210	5,135	56,345
March-July	Dry	-	95,785	95,785
Year		120,630	107,880	228,510

Table 2 Hawata town hafir storage operation, 1983

Month	Start		With-drawals	Losses					Total depletion
	Water Level m	Storage m^3	m^3	Evapo-ration m	Seepage m	Total m	Mean water surface area m^2	Lost volume m^3	m^3
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Jan	11.510	151,500	1,735	0.226	0.060	0.286	44,000	12,580	14,315
Feb	11.120	137,185	1,735	0.230	0.060	0.290	34,500	10,005	11,740
Mar	10.750	125,445	19,150	0.295	0.060	0.355	18,000	6,390	25,540
Apr	9.410	99,905	19,150	0.309	0.060	0.369	15,060	5,555	24,705
May	7.900	75,200	19,150	0.249	0.060	0.309	14,000	4,325	23,475
June	6.100	51,725	19,150	0.192	0.060	0.252	10,750	2,710	21,860
July	4.080	29,865	19,150	0.114	0.060	0.174	8,200	1,430	20,580
Aug	1.530	9,285							

Table 3 Approximate costs for Hawata emergency water supply

(Based on information available at mid-December 1982)

CONSTRUCTION	LS	LS
Earthworks		
1. Repairs to hafir banks: Excavation, placing and compaction to fill erosion gullies: 247.2m³ @ LS6.500		1,607
2. Mini-barrage in Rahad River: Filling sacks with excavated material and placing, including placing of pipes (supplied by town) in embankment, and supplying and placing supported stakes: 10,000 sacks @ LS0.200	2,000	
3. Supply of 10,000 sacks @ LS0.550	5,500	
		7,500
Pumping installation		
4. Supply of flexible pipe and pipe fittings.	950	
5. Supply of three Godwin/Lister G3/LT1 pumpsets, 84m of 6in and 36m of 3in steel pipe from UNHCR store	No charge	
6. Supply of local materials and cost of local labour	200	
		1,150
TOTAL		10,257
OPERATION FOR 1 MONTH (NOV/DEC)		
1. Wages for pump attendant and guard		135
2. Diesel fuel and lubricating oil		550
TOTAL		685

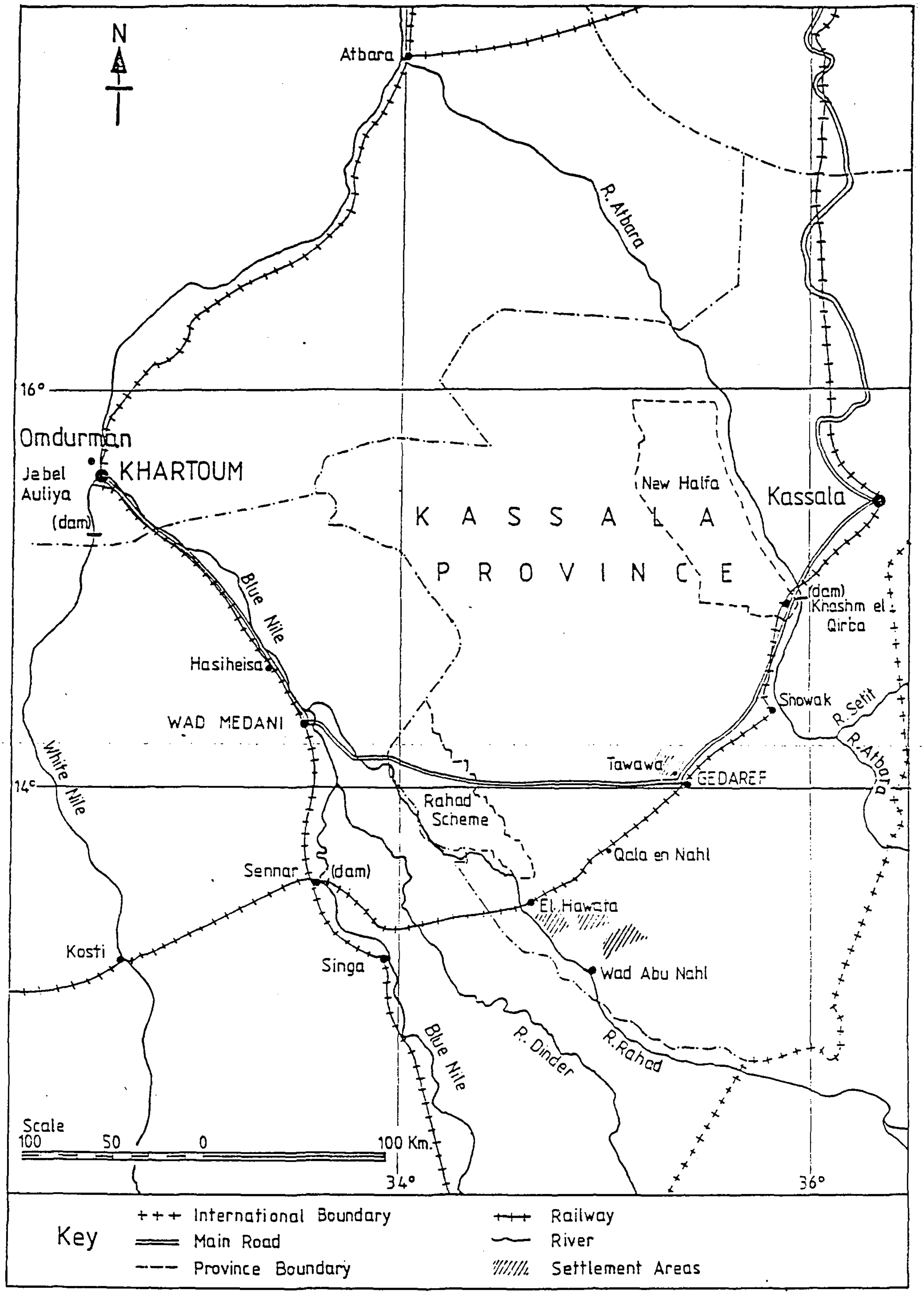


Figure 1 - Location Map

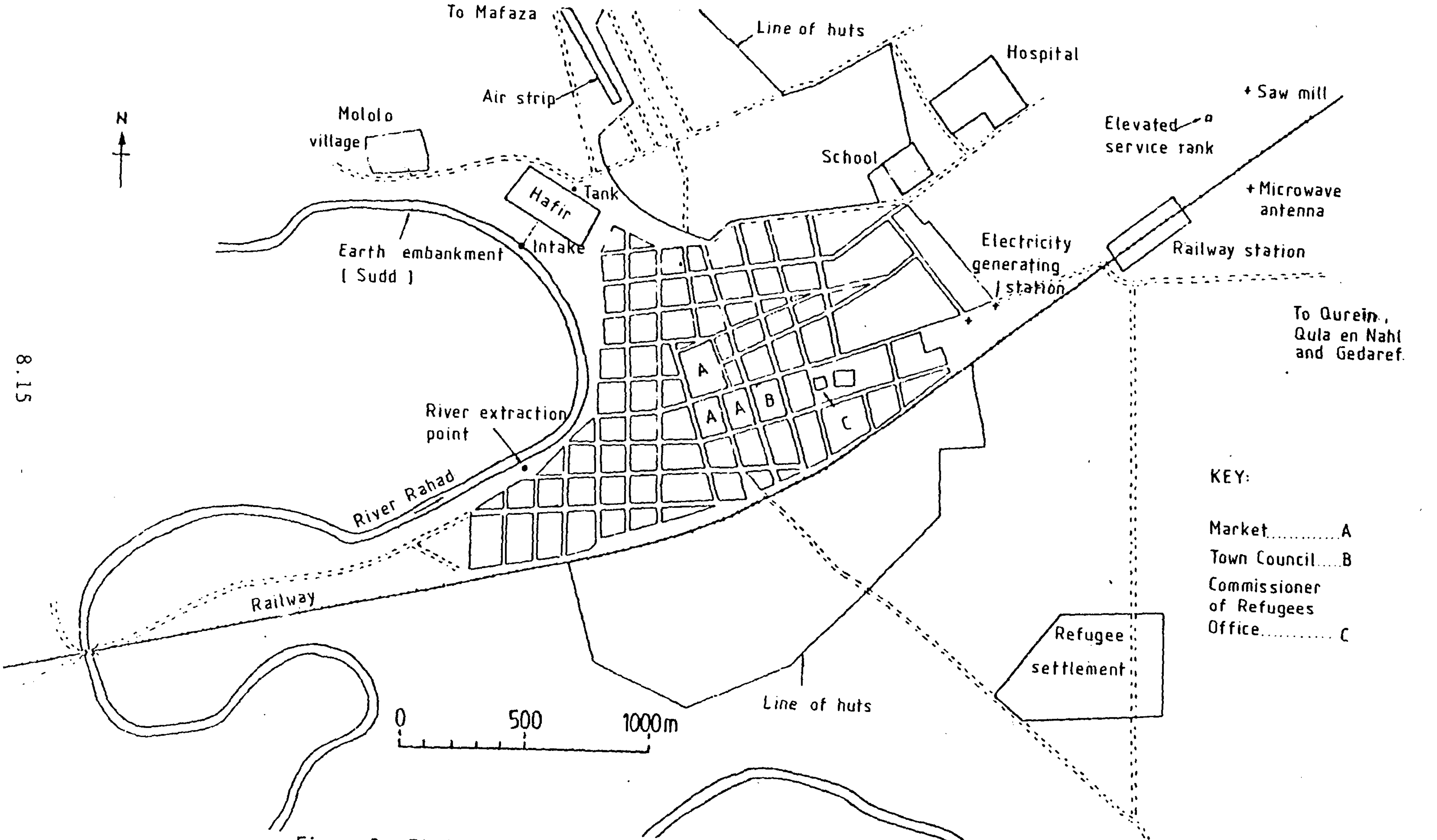
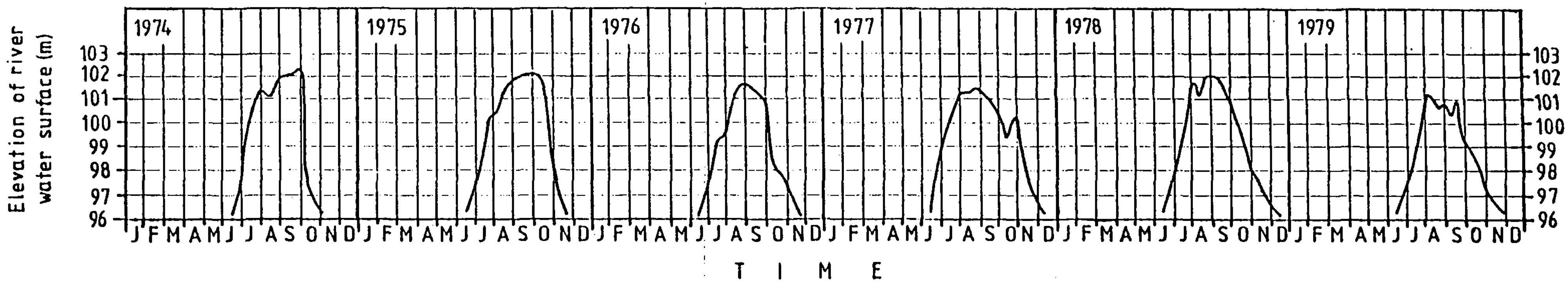


Figure 2 - El Hawata Township Area



Notes

1. 10 Day mean values have been plotted.
2. Elevation 100.000 is the Bench Mark set up by the NAW site investigation, February 1982.
3. Elevation 95·000 is approx. river bed level at intake site.
4. For elevations of proposed hafir embankments and original ground levels see drawings for Contract Nº 1

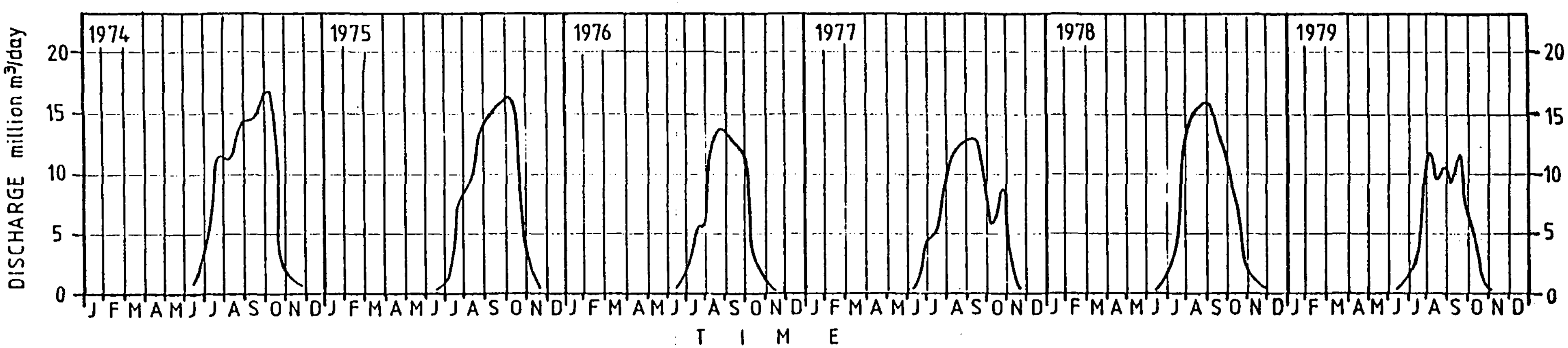


Figure 3 Water Levels and Hydrograph of the Rahad River 1974 - 1979

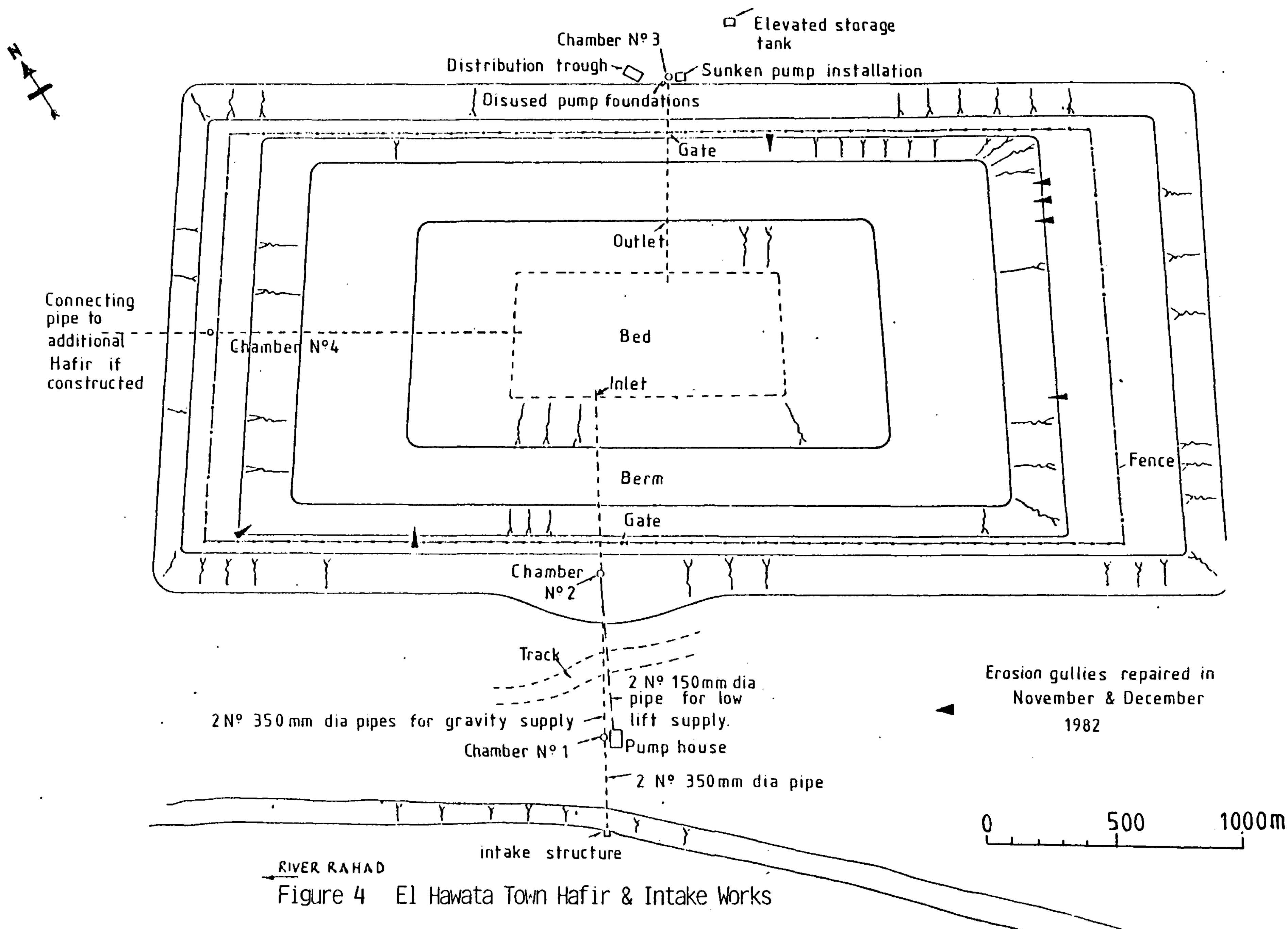
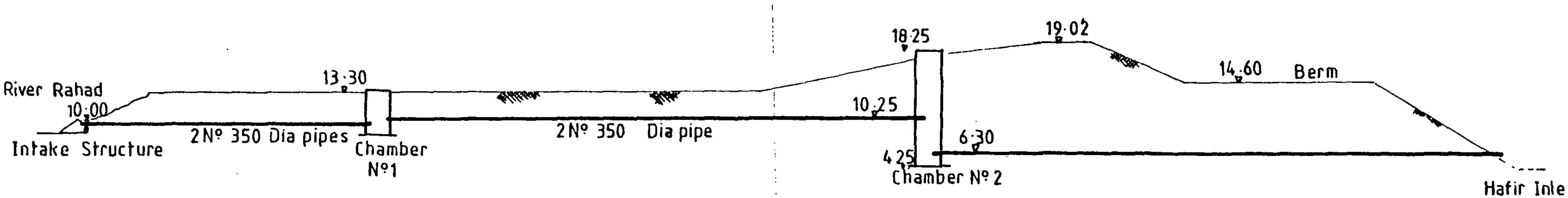
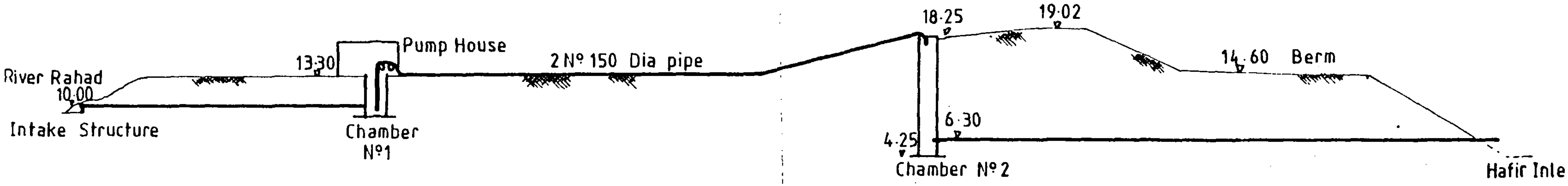


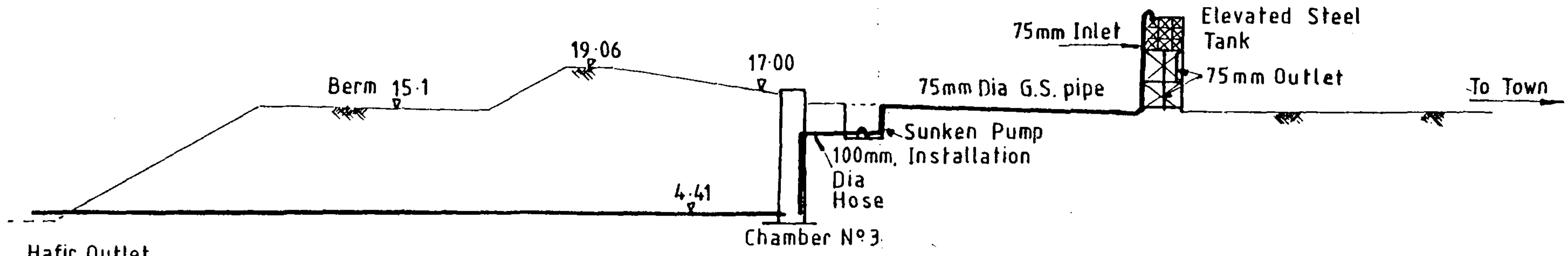
Figure 4 El Hawata Town Hafir & Intake Works



SECTION THROUGH GRAVITY SYSTEM



SECTION THROUGH LOW LIFT SYSTEM



SECTION THROUGH OUTLET SYSTEM

FIG 5 - El Hawata Town Hafir - Longitudinal Section Through Intake & Outlet Systems

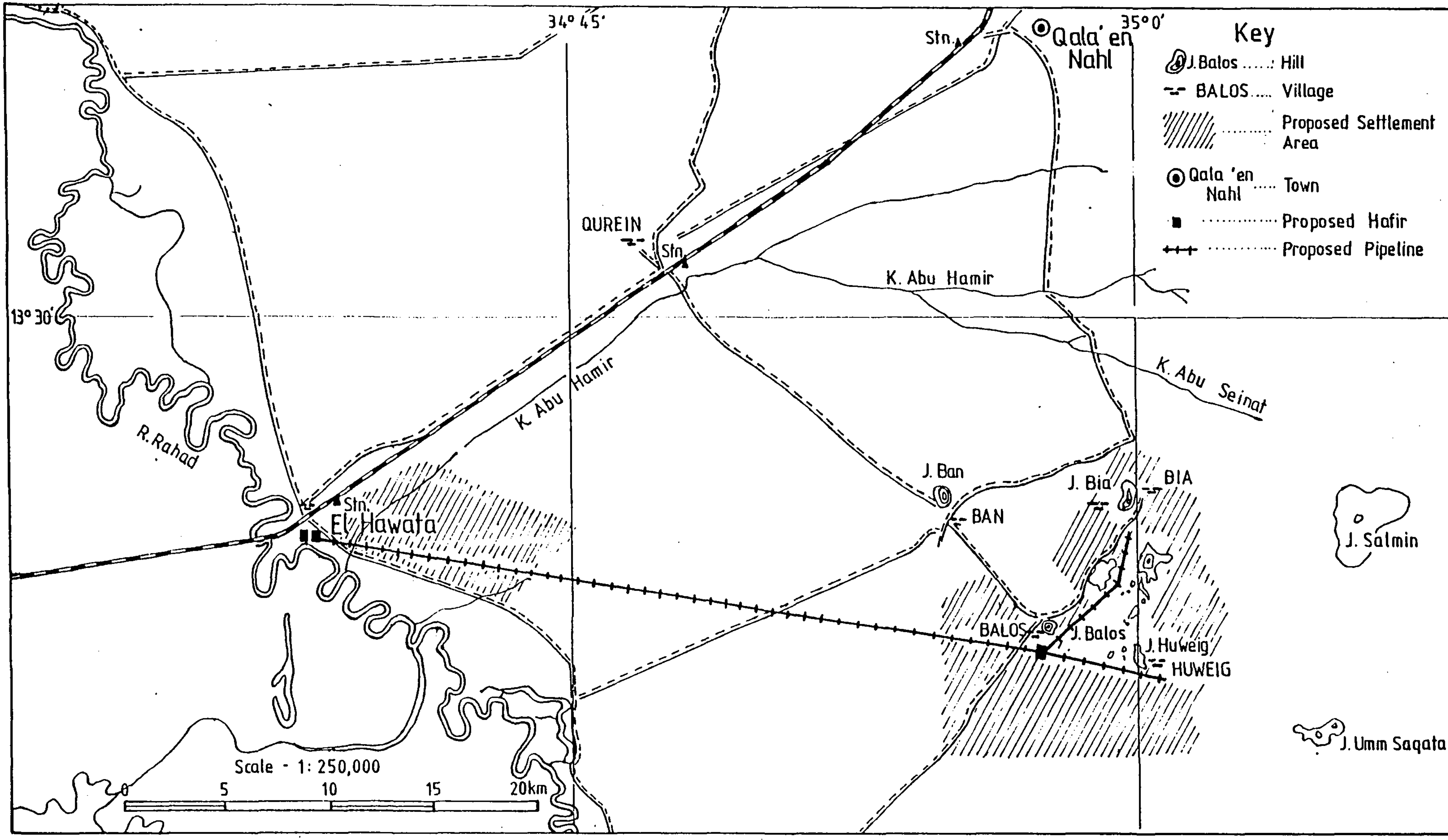
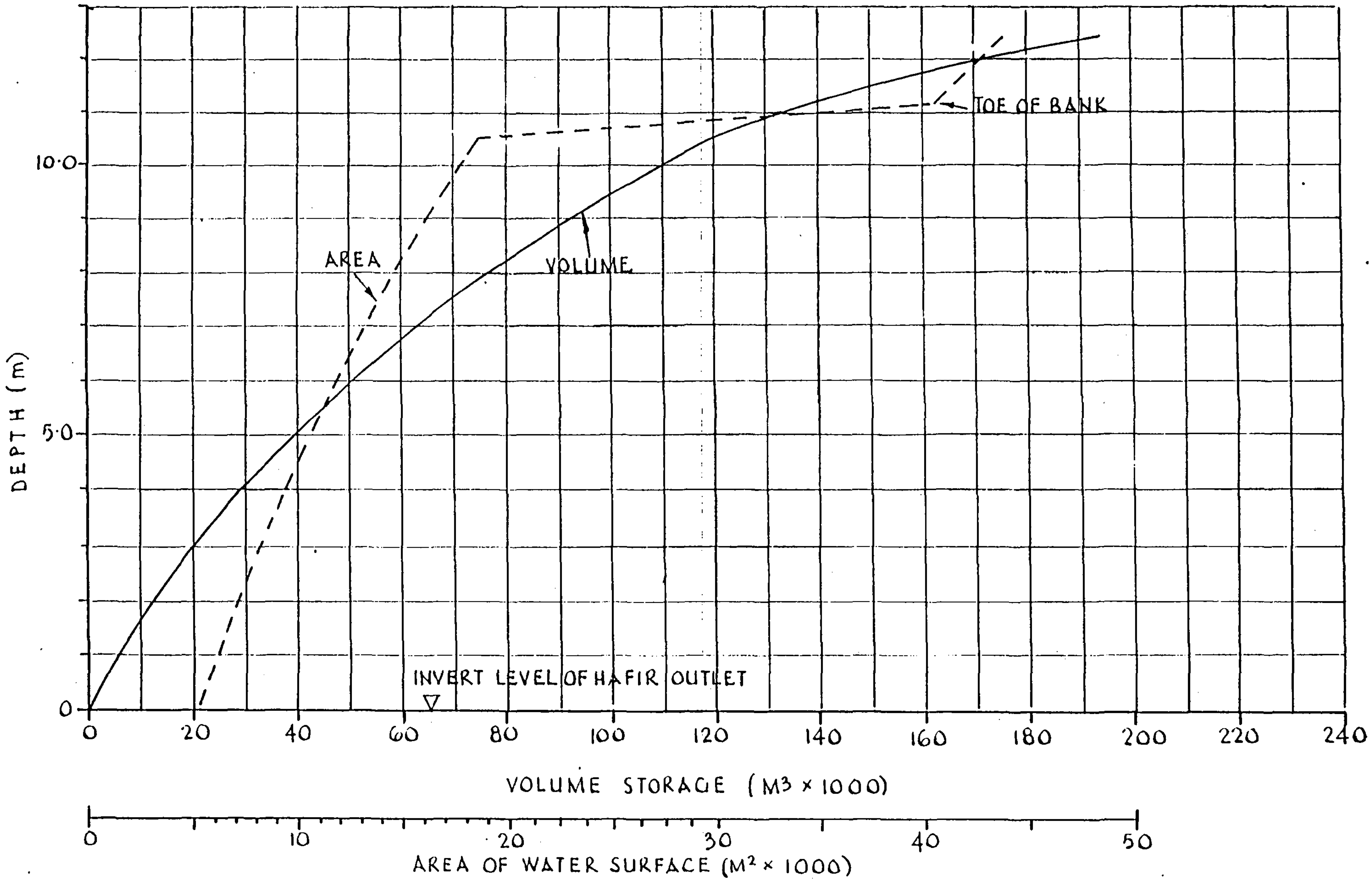


Figure 6 Qala en Nahl / El Hawata Project



NOTE : VOLUMES SHOWN ARE 'ACTIVE' STORAGE VOLUMES.

FIG 7- El Hawata Town Hafir - Depth, Storage Volume and Surface Area

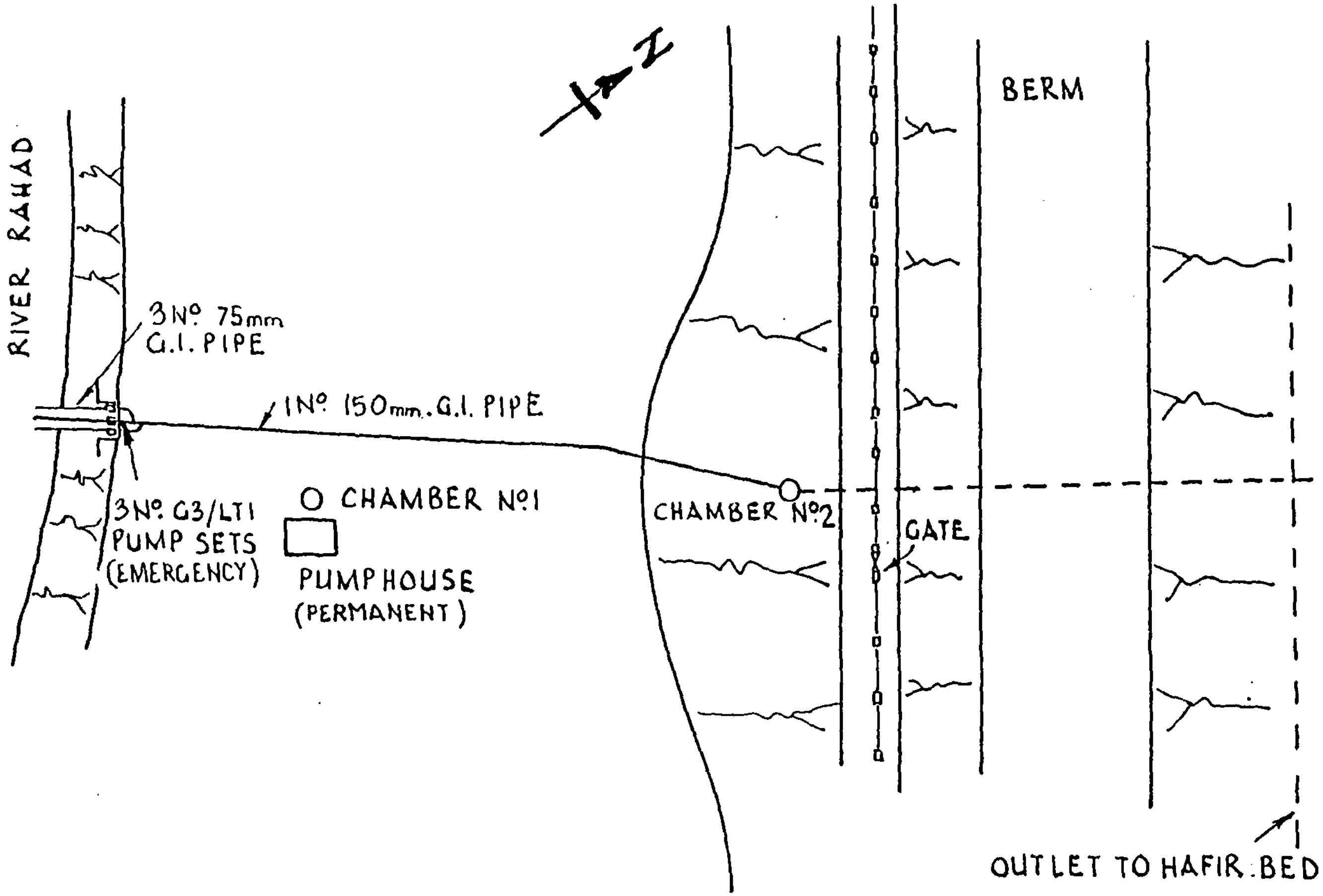


FIG 8 - El Hawata Emergency Pumping Installation

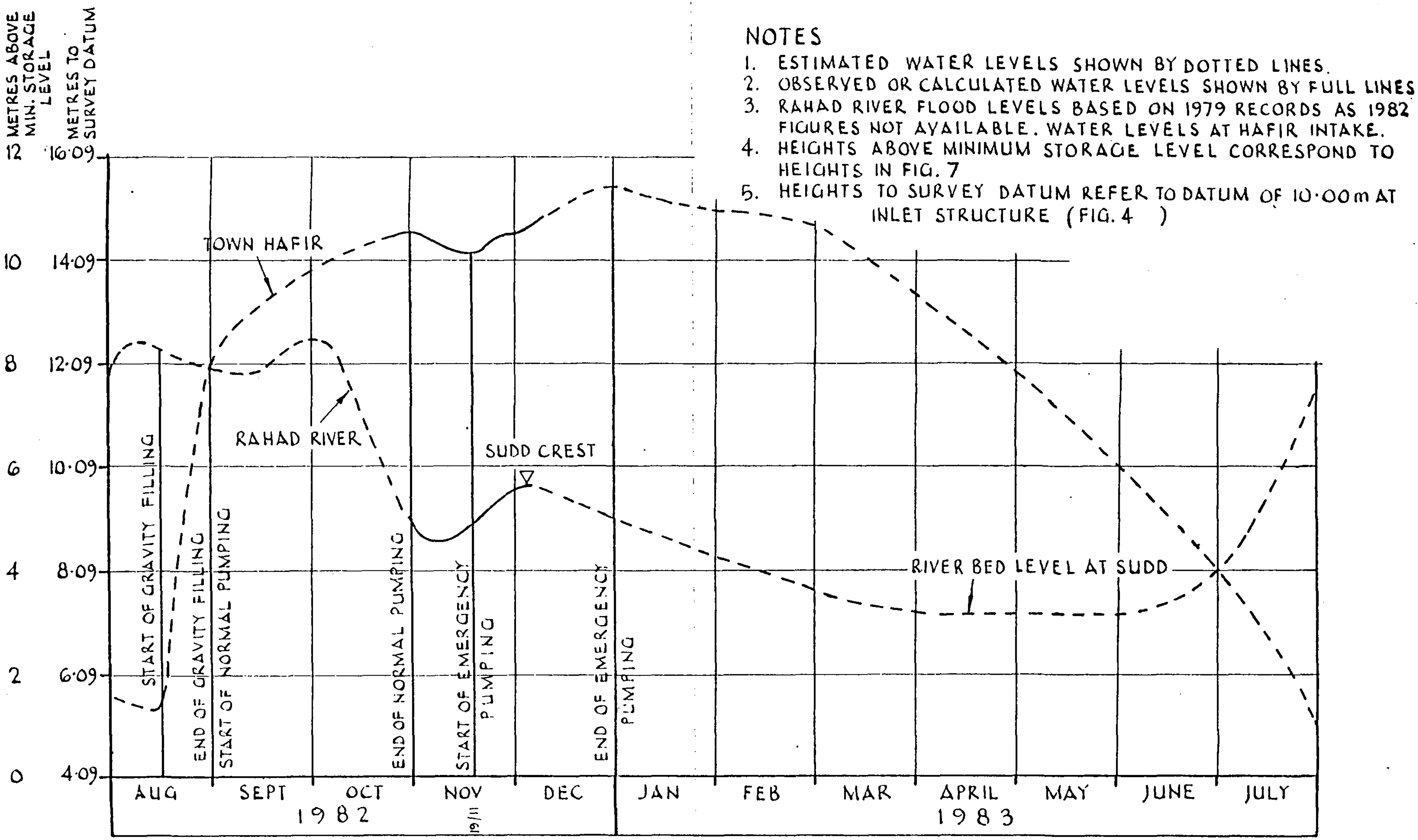


FIGURE 9 El Hawata Town Hafir and Rahad River Levels, 1982-83

PAPER 11

URBAN LOW COST SANITATION IMPLEMENTATION

BY

JOHN ASHWORTH

HALCROW-BALFOUR LTD, U.K.

1. SUMMARY AND CONCLUSION

In many third world countries the acceptance of urban excreta disposal systems, such as the ventilated improved pit (VIP) latrine, has not resulted in the mass acceptance and implementation of the designs nor a reduction in the water related diseases they are expected to relieve.

This paper proposes guidelines for undertaking an urban, not a rural, sanitation project that may, with changes for local circumstances, be suitable in many countries. The proposals are based on those used in east Africa: the participation of the people, not in the manner of a self-help rural project, but in conjunction with the official urban body in charge - the Low Cost Sanitation Unit.

It is proposed that the Low Cost Sanitation Unit be staffed by health inspectors who are already trained both in the construction of latrines and health education. Thus, it may not be necessary to establish a new department, but rather strengthening an existing one.

The participation of the urban people with the project will allow taboos and prejudices to be revealed in advance of the main construction programme. If objections are such that a change to the latrine design (that is, squat or raised seat) would ensure user acceptance, then this can be done after the demonstation project stage and before the main implementation of the programme.

A latrine project without a health education programme will have marginal success in deducing water related diseases. Where funds are restricted the target for education should be school children, who are the most receptive to new ideas. But adults cannot be ignored as it is they who have to agree to the construction of the latrine in their homes and, without their co-operation, the latrines will not be built.

2. THE PROBLEM

Disease

The danger of bad urban sanitation is in the spread of the water related diseases. The continuing problem of children suffering from gastro enteritis, who then contract measles or malaria and die of the joint effects, does not abate as whole families continue to be wiped out. Only when major outbreaks of cholera or typhoid are reported in the national press do politicians show great concern - for a short time.

Feachem (reference 1) et al have clearly shown the relationship of poor sanitary conditions to water related diseases. Most professional people now accept that a radical improvement in the public's health can be obtained by the provision of a combined excreta disposal system and health education.

DISEASE CLASSIFICATION (reference 1)

Category

1. Faecal-oral (water-borne or water washed)

   a) low infective dose
   b) high infective dose

2. Water-washed

   a) skin and eye infections
   b) other

3. Water-based

   a) penetrating skin
   b) ingested

4. Water-related insect vectors
   a) biting near water
   b) breeding in water

3. THE SOLUTION

Provision of excreta disposal system

The United Nations Water and Sanitation Decade has led to the review of many excreta disposal systems. It has been accepted that the principle designs of the main urban systems are:

1) full water borne sewerage for the high density town centre (10% of the population).

2) septic tanks for the high income low density quarters of the town (10% of the population).

3) small bore sewerage for high density middle income house-holders where density, poor soil strata or high water table precludes septic tanks, or pit latrines. (Up to 10% of the population).

Sullage disposal

The development of a satisfactory non-sewered excreta disposal system has drawn attention to the often squalid conditions resulting from urban sullage disposal. During the rainy season, it is common in slum development areas, to see pools of black sullage being played in by bare footed children and adults walking through it. Under appropriate conditions these pools are the breeding ground for the culex mosquitoes - the vector of Bancroftian filarisis. Where open defecation takes place, hook worm can thrive in the wet conditions and the bare footed populus contract the disease.

In parts of east Africa the washing slab (reference 2) has been in use for several decades to control the sullage problems. The concrete waist high slab is used by the woman of the shamba preparing food and carrying out her domestic chores. The waste waters drain through a trap into a soak pit beneath.

Refuse disposal

Greater attention is now being given to refuse disposal: inefficient disposal is often the cause of rat and flea borne diseases (for example, typhus). Simple skip containers or trailers located within 100 metres of homes are being introduced. When prosperity warrants it, dustbin collection services will be instigated.

Sociology

Yet, even with the provision of these hardware items for removing man's wastes, there is only limited success in reducing the water related diseases. The main areas of failure are:

1) persuading people to accept, and thereby want, the disposal facility - pit latrine, washing slab.

2) building the ventilated improved pit (VIP) latrine, or whatever facility is required.

3) using the latrines in a hygienic manner by an understanding of possible health dangers.

4) making personal hygiene part of everyday life.

The problem of persuading peri-urban dwellers of the need to use latrines is usually related to the length of time they have lived away from the village. Tribal customs and taboos form an important part in the culture of the people, which are lessened only by becoming accustomed to town living.

Once the proposal to build, say, a VIP latrine is accepted, all sorts of objections can arise, such as the householders lacking the necessary funds, or the house may be rented and the landlord is on safari. It is tempting for western engineers to dismiss such problems as being no concern of theirs. However, slowly people are realizing that they must actively participate in dealing with such problems.

One recent example was the provision of easily identifiable white superstructured latrines in open areas. Although an excellent advertisement for a new sanitation scheme, it was a failure, in that nobody used the latrines. Eventually, it was discovered that the rural community believed in the power of the witch doctor to harm then by casting spells over a sample of their excreta; the villagers continued to excrete in the secrecy of the bush away from prying eyes. Engineers are now understanding the importance of sociology and how it effects their work.

Engineers are also learning that letting a contract to build a 1000 latrines for a community, without time allocated for personal contact with the people being served, generally fails to meet the full potential expected by the client. In the same way, a contract to provide Asian squat lavatories in France is likely to be acceptable, but is a disaster in England.

A double vault alternating ventilated improved pit latrine might by highly successful in one town, but 40 kilometers away, in an area where the ground water table is high and people are accustomed to showering in the latrine, a single VIP Latrine emptied by a vacuum tanker would be the answer not a double vault alternating pit latrine.

Quite often the different requirement is not 40 kilometers away, but within the same town.

The sociologist's input is essential in aiding the engineer and governments with such social problems and how best to overcome them for a particular project.

Health education

To the surprise of some western engineers in the 1960s and 1970s, the provision of a modern sanitary system to a third world country had limited success in reducing water related diseases. The concern can be imagined, when after a large capital expenditure on yet another urban service, there was no reduction in gastro enteritis and the other water related diseases. With many governments under pressure from the rural communities to reduce urban budgets, the important of health education, combined with a sanitation project, becomes a paramount requirement.

Health education combined with a sanitation project is attractive as a means of introducing preventive medicine to the people. Even western governments are spending more money on such concepts, as witnesses by the anti-smoking and junk food campaigns. (Third world countries do not require such campaigns as their life expectancy is below the age that causes concern in the west! It is noted that kwashiorkor can be a serious problem to children).

However, it is not necessary to invent health education policies and programmes but reintroduce what has been used before and since lapsed. Prior to their independence, east African countries were operating health education programmes through several channels. Two of these programmes were:

1) School health science period.

   As part of the primary and secondary school curricula, the children were taught personal hygiene, dangers of poor sanitation, food preparation and so on.

2) Health inspectorate, who were based in every township, has a multiple role from meat, food shops and market inspections, to holding antenatal health education classes. During epidemics the health inspectorate implemented that mass health campaigns to emphasise the particular dangers of the disease, the importance of boiling water and so on.

In addition, the health inspectorate was trained to supervise any local applications for pit latrines or septic tanks construction submitted to the town council for approval. It is clearly not always necessary to develop a new body to undertake the health education requirements needed by a sanitation project. The programme and syllabus are there as well as the professional body to implement them. It is a matter of reviving both, to meet the present demands.

Adult health education?

Where resources are available, campaigns must include the adult population. Regrettably, the older a man becomes the less susceptible he is to new ideas, and the taboos learned in childhood are likely to remain with him for life. This is borne out by health clinics where mothers bring their children suffering from kwashiorkor. Mother and child stay at the clinic until recovery is complete, during which time the problems of protein deficient diet are explained and discussed. Yet, six months later the same mother returns bringing a second child suffering from the same disease.

Where resources are limited the health education campaign should be directed to the school children who are maleable and amenable to new ideas: the children of today are the adults of tomorrow. But an adequate proportion of funds must be made available to educate the adults, as it is they, particularly the men, who have to agree to the construction of the new VIP latrine in the home.

4. URBAN LOW COST SANITATION: IMPLEMENTATION

The implementing agency

The foregoing considerations define the requirements of a low sanitation project as:

1) the design of latrines and washing slabs to the particular requirements of the people.

2) the participation of the people in the approval and implementation of the construction project.

3) the combining of the above with health education, to effectively reduce the water related diseases by preventive medicine.

The establishment of a low cost sanitation section along with lines set out in Figure 1 is proposed. The formation of such a section within the health department would cause little difficulty as the health inspectorate are, in many countries, already responsible for similar duties. The Chief Health Inspector would direct the section's two units whose different functions would be:

1) Health education Unit: to train the school health science teachers, undertake adult education classes and to liaise with the Sanitation Extension Unit.

2) Sanitation Extension Unit: to establish a demonstration pit latrine and washing slab project at local schools and in public market places. To liaise with the local representative (in east Africa, the ward chief), to organise meetings for viewing and discussion of the demonstration project and, later, to undertake a household consultation to gain agreement for the construction of the new latrine, where it is shown to be required. The Sanitation Extension Unit would then instruct a local contractor to build the latrine, and cover all aspects of planning approval and certification of building works. Finally, in conjunction with the local representative (ward chief) the collection of monthly loan repayments.

The low cost sanitation staff shown in Figure 1 are primarily of paramedical background. It is not necessary to fill the posts with the exact designated classification, but to create a career with prospects of promotion. A hierarchy system has been chosen. For instance, health visitors can train to become health inspectors and health inspectors can attend courses to qualify them for the post of senior health educator.

Health Education Unit

The unit, although based in the municipality would work in conjunction with the National Health Ministry and its Health Education Department. In many countries this department provides poster pamphlets, radio broadcasts and guidance on street theatres and comic strips to put across the current campaign.

The Health Education Unit's primary task would be to strengthen the school health science teaching. Workshops would be held for the school teachers in advance of the demonstration pit latrine project, to enable the health inspectorate to concentrate on adult health education classes during the demonstration project. The classes for the mothers would be run by the health visitors and welfare workers in conjunction with their everyday duties at the health clinics and women's clubs. The task of changing the adult sanitation attitudes will not be easy and procedures such as impromptu meetings and street theatres would have to be tried. More formal meetings at the school, in the form of parent teacher meetings may result in the men becoming receptive to the health programme.

Sanitation Extension Unit

The Sanitation Extension Unit has the difficult task of co-ordinating the health education in conjunction with various steps to ensure the successful conclusion of the project. Each project will demand different solutions but a programme might cover the following:

1) Demonstration project

Before committing major expenditure it is necessary to gauge public reaction to the pit latrine and washing slab designs. Aspects that are not liked can be changed before the main scheme starts. In conjunction with the Health Education Unit, the demonstration project would be started in a public place, such as a market, but, preferably, at a local school for the following reasons:

a) Many schools have insanitary conditions, as services have not matched the increased numbers of school children. Often, the existing flush lavatories are serious health hazard, owing to lack of water or sewer pipes blocked by corn cobs used for anal cleaning.

b) Schools act as a focal point for the community. Parent/teacher meetins are held to discuss problems and to co-operate on, for example, the building of a new classroom.

c) During the construction of the school latrines, the children would be reporting back to their parents on the progress being made and the eventual inauguration of the scheme.

d) By employing a local contractor to build the latrine, artisan parents of the school children are likely to be employed in its construction. The artisans would gain experience of new building procedures such as the precast concrete floor slab and hopefully later undertake the private construction of similar latrines in the district.

2) Household extension operation

Continuing in the district of the school demonstration project, the Sanitation Extension Unit, consisting of say, a health inspector and a health visitor would collaborate with the ward chief to survey the houses in the district. The survey would determine those households immediately needing a new improved pit latrine. A meeting would then be held with the houseowner to discuss the latrine requirement and how all parties would help to resolve any problems. Gentle persuasion and a reminder of the school latrine project would be followed, if necessary, by pressure from the ward chief.

The Sanitation Extension Unit would discuss the possible options available to the houseowner to finance the cost of the latrine. In the case where the landlord fails to provide the latrine the council shall direct that the rent be witheld until the cost of the latrine has been met.

The Sanitation Extension Unit would be responsible for overseeing the building of the new improved pit latrine, from the stage of obtaining planning approval from the town council to checking the construction.

On completion of the pit latrines, the Sanitation Extension Unit would review the use of the latrine by the household and help where necessary. The Health Education Unit, at the same time, would concentrate its programme in the local schools and adult education centres.

3) Contractor built latrines

Self-help constructed latrines reduce to a minimum the cash outlay required from the householder, who may even be able to undertake the pit excavation. However, it is not feasible, either to check the competence of each householder, or to train each to the required level in the effective use of reinforced concrete and other building practices. A few qualified artisans, in each district, trained to the appropriate level, could establish themselves in the art of pit latrine construction, and their skills would remain within the district to provide for the continuing pit latrine demands.

Another option is for the town council to provide a pit latrine construction service, using its own labour force. From experience in other African countries, this is not always satisfactory. For example, transport may not be allocated for the delivery of materials: the labour force is paid the minimum government wage, consequently lacks the incentive to work and the valuable materials such as cement and steel may be misplaced. The eventual cost of the latrine becomes much greater then originally priced.

Contractor-built latrines absolve the council from the above difficulties, although the council would be required to supervise and certify the works. Small local contractors are the most suitable to undertake this work, as they will recruit locally and can readily undertake the construction of a small number of latrines. The latrine is contracted out for an agreed competitive price and the incentive is then with the contractor to complete the work efficiently.

The Sanitation Extension Unit could aid those householders who wish to build their own improved latrines by producing a pit latrine kit available for purchase from council depots. The kit would consist of a latrine construction booklet, a precast concrete squatting slab, a vent pipe, a squat hole fly trap or wooden cover and glass fibre mosquito gauze to cover the vent pipe. There could be an option to purchase corrugated iron roofing sheets and roofing nails. It would, however, require good organisation to ensure that production and availability of these supplies.

Cost recovery

Historically, developing country governments have spent public funds in providing services to urban rather than rural population. These funds are raised by taxation of the people including the rural population. The imbalance in services received by the rural and urban population has led to the policy that all people should pay for the services they receive, and only in cases of extreme poverty should the government give financial support. Similar cost recovery policies are proposed for a latrine project.

The better-off urban householders can provide a subsidy to the poorer urban households through higher charges for services than are economically necessary. The provision of a hygienic sanitation facility to the poor does benefit the richer householder, insofar as there is less risk of an epidemic for the whole community. Some methods of financing, or recovering the cost of, the construction of pit latrines are considered below:

1) Through beer clubs or similar societies, poor people are able to raise cash to finance capital expenditures. The clubs allow individuals to drew and sell millet beer in rotation and the customers pay up to US $1.50 per sitting, resulting in a profit for the duty publican. The profit could be used for direct financing of a latrine.

2) Municipal and government employees might be given credit, to be repaid by deduction from their monthly income. for example a US $125 loan repayable over 15 years at 5% interest per annum would require a monthly repayment of US $1 per month.

3) For poor people, cost recovery is difficult to operate. One possibility is to provide credit and for the recovery to be through a surcharge on the municipal tax. Ward chiefs would be co-opted to assist in the recovery, as they generally assist in the tax collections.

The above possibilities will always result in some default of payments. Each case will have to bear the loss; hopefully, such subsides will be small and justified by the benefits to the whole community.

Flexibility

As low cost sanitation departments gain experience, changes of both policy and facilities will be needed. It is never possible for a central organ to dictate the exact procedures to be followed for a successful project. It is important to believe in the intelligence and ability of subordinates, and, their initative and enthusiasm to remain alive for the success of the disease preventing project.

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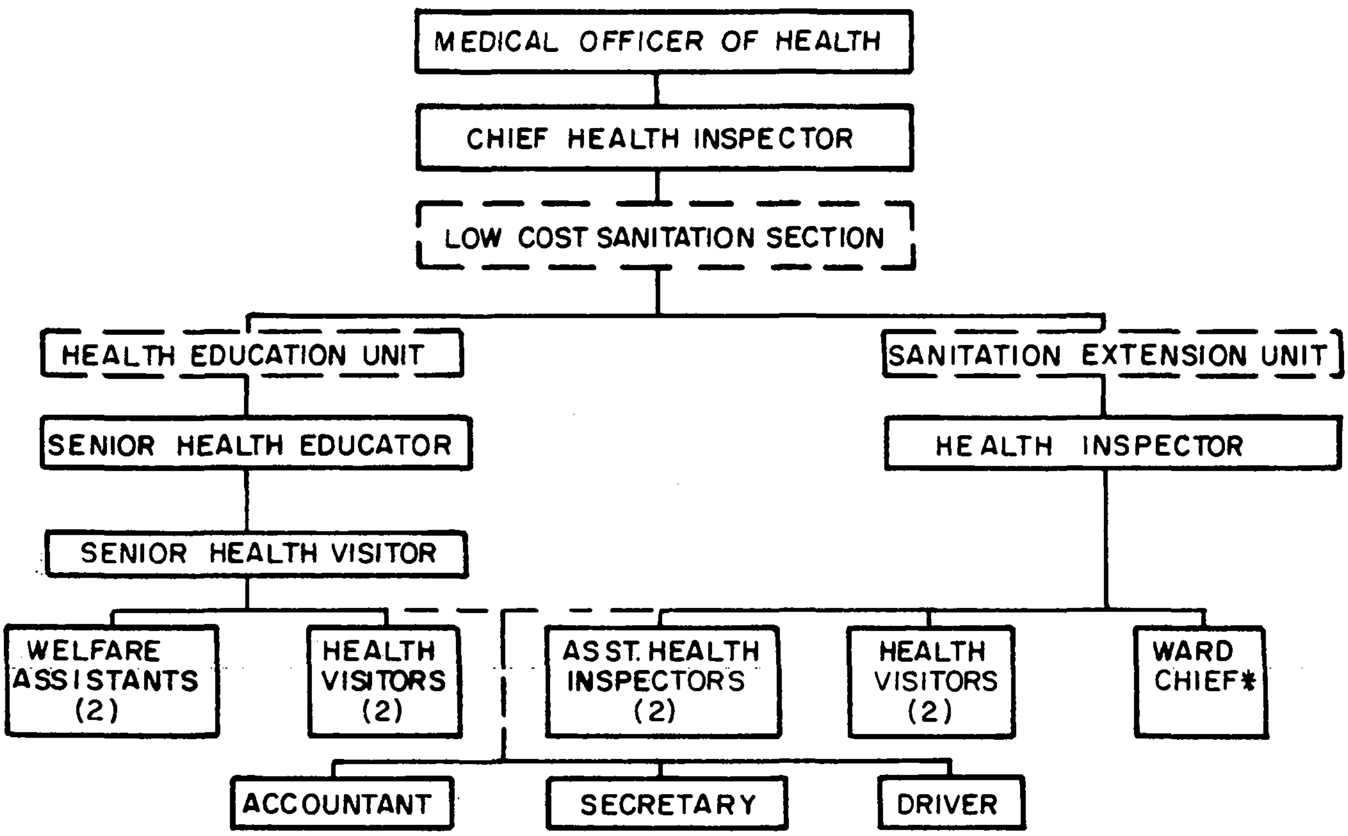
TOWN COUNCIL

LOW COST SANITATION DEPARTMENT



NOTES:-

1. Health Education Posters, Pamphlets, etc. produced by the Ministry of Health Education Unit.
2. The Town Engineer's Draughtsman to be available when required.
3. The Secretary, Accountant and Driver are to be shared by the Units.

* The Ward Chief is the East African term for a community represenative. He would not be a council employee, but remain in his official government post

FIGURE I.

VIP LATRINE
A health inspector checking
the construction progress

PAPER 12

PROFESSIONALS AND PEOPLE IN AFRICAN WATER TECHNOLOGY

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THE DECADE

No apology is needed for returning to the theme that professionals need to be concerned with people. Water and sanitation technology must benefit people and the people must be involved at all stages if the Water Decade is to be at all successful.

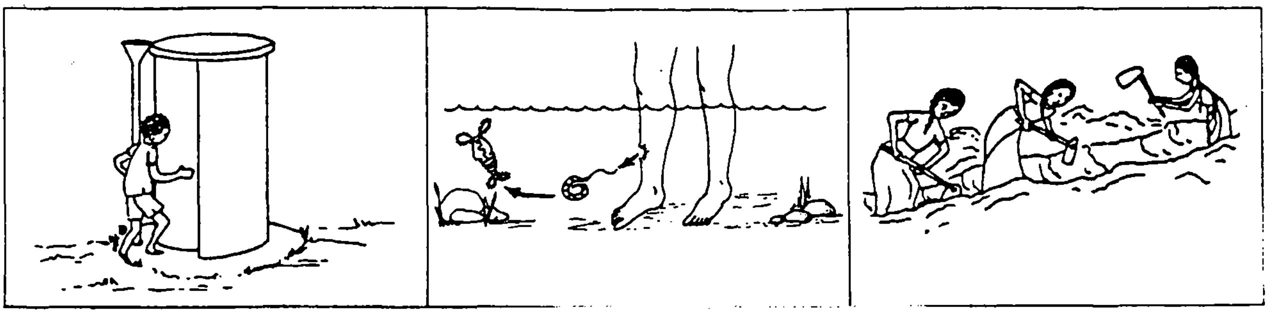
The Decade seems to be a frequent target for sceptics, many of whom take a sadistic delight in what they call the 'failure of the Decade'. Personally I am certain that the International Drinking Water Supply and Sanitation Decade has already succeeded to a remarkable extent. This success is not so much in the number of people who have a new supply of good clean water and even less in the numbers who are newly connected to sewerage. Such statistics as are available indicate that the sceptics could be right. Certainly as far as Africa is concerned there will be a few countries approaching 100% coverage for water supply by 1990, and over the continent as a whole only a tiny proportion of the total population will be connected to properly-operating water-carried sewerage and sewage treatment systems by 1990 or even by the end of the century in 1999. I think the decade's achievement has been in an upsurge of interest throughout the world and a change of attitude. Conferences like this are indications of the increased interest. This paper is partly concerned with the change of attitude.

Consultants and the Decade

Immediately after the 1977 Water Conference at Mar del Plata in Argentina at which the Decade was conceived, a lot of consulting engineers throughout the world rubbed their hands in delight. They envisaged the release of an uprecedented flow of hard currency for projects which would require their services. Every city and town would have consultants' water and sewerage master plans followed by consultant-designed and consultant-supervised implementation.

This was not to be. The flow of money never materialised, partly because of the world's economic situation and partly because of new ideas which have gradually permeated through the whole of the third world. For governments and consultants expecting conventional piped systems the greatest disappointment has been the World Bank, which has failed to release a flood of money. In 1983 IBRD and IDA mad only seven loans in the water/sanitation sector for the whole of sub-Sahara Africa. They totalled US $95.2 millions, compared with S100.3 millions for Mexico alone and $302.3 millions for Brazil (reference 1).

The World Bank has also combined with UNDP to devote a great deal of effort (and presumably a lot of money) to support studies into what is known as 'appropriate water and sanitation technology'. This technology seems to consist only of advocacy of ventilated latrines, a lot about diseases with peculiar Latin names and rather vague discussion of women's involvement and such-like. Not much hope for conventional governments and engineers here.



From the professional engineer's viewpoint there has been a little encouragement. Nigeria for a time provided a promising field for master plans, with a steadily increasing number of state capitals vying with each other to provide the most lavish infrastructure (see for example, reference 2). The price of oil fell, and with it Nigeria's economic strength, before these plans were implemented - in some cases before consultants had been paid for their master-planning. One notable sewerage project in Africa is the Greater Cairo Wastewater Project (reference 3). Hundreds of millions of dollars are being devoted to this, although even in Cairo some attention has been given to unsewered sanitation. Africa has had several other new major water and wastewater schemes. For example a new treatment plant for Harare's sewage is designed for a very high effluent standard (reference 4).

However, such projects are not really connected with the Decade. They would probably have gone ahead without it. Some of them are additional benefits for those who are already well-off in terms of infrastructure, rather than providing a service for the underprivileged majority.

WATER AND SANITATION FOR THE UNDERPRIVILEGED

When we come to consider new supplies for people who previously obtained their drinking water from distant, scarce or polluted sources and good sanitation for those who previously defecated indiscriminately or in foul, disease-spreading latrines, we are in what the Americans call a different ball-game.

The Decade is for the have-nots, who in Africa greatly outnumber those who already have good water and sanitation. In general those living in rural areas and unfavoured districts of towns and cities not only lack easy access to good water and sanitation. Most live in crowded sub-standard dwellings and have a struggle to get enough food to keep body and soul together. Just from the point of view of cost the level of water/sanitation of Europe and north America is out of proportion to this low socio-economic level.

SCALE OF WORK

The size of appropriate units for Decade-type water and sanitation programmes is often completely different from that of conventional public health engineering practice. Typically the unit for water supply is a handpump serving a few households all within a few hundred metres. This contrasts with an urban supply which usually -

* takes water from a source many kilometres away
* treats the water by methods which require power and chemicals
* transmits the water by pumping using electricity or diesel fuel
* delivers the water to customers who have no concern with how or whence it comes.

The development of good handpumps such as the VLOM (village level operation and maintenance) has received much attention (reference 5). Gravity-fed schemes, like those in Malawi (reference 6) have great advantages. Similarly, where treatment is necessary gravity should be used as much as possible (reference 7).

The typical unit for Decade-type sanitation is a ventilated pit latrine serving a single family or a group of families sharing the same compound (reference 8). Often the pit is dug by the future users, who may also make the squatting slab and build some kind of shelter or superstructure. This compares with water-carried sewerage, which to function properly usually requires -

* a continuous and ample supply of water
* unblocked drains and sewers
* sewage pumping unless there are adequate natural falls (which there rarely are)
* an adequately-maintained treatment works
* disposal which is appropriate for the use of the effluent, the dilution in the receiving stream and downstream abstraction.

While the provision of handpumps and pit-latrines may typify the Decade's achievements there are two areas of work which deserve comment before we consider the people (professional and otherwise) whose work is vital for the Decade.

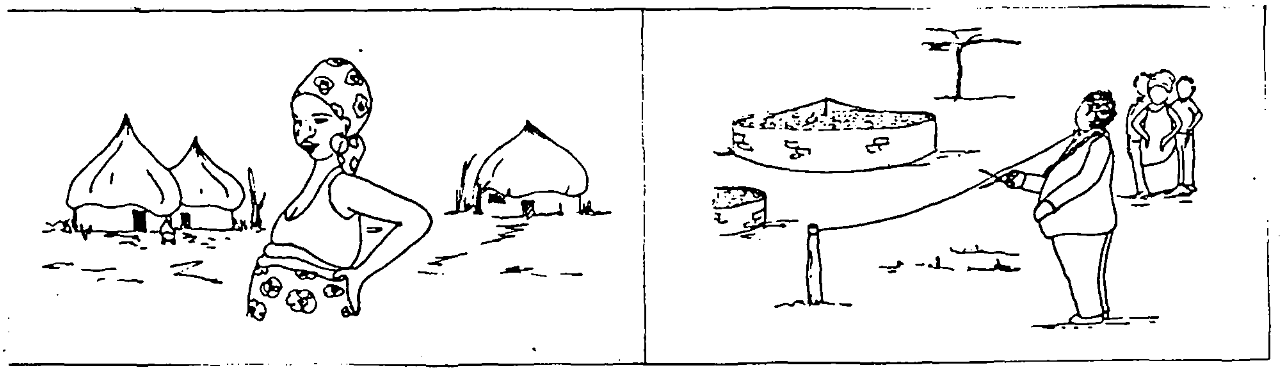
a. Water supply for underprivileged urban communities is usually provided by an extension of the general urban system. In effect these people often get what's left after the well-off are satisfied. Funding agencies constantly demand that water authorities should balance their books. So authorities inevitably give most attention to those who can provide them with income. A standpipe supply gives less health benefit than household connections because the water used per person is less, but this in turn has advantages because there is less waste water.

Some time ago I was talking with an expatriate consultant in an African city. He was working on the design of a water supply project of an underprivileged area of the city. House connections were to be provided. The basis of his calculations, he told me, was 576 litres per person per day. He could give no reason for choosing 576 rather than 550 or 660. More to the point he could not explain why the design flow should be more than ten times what standpipes would deliver, nor what would happen to all this water after it has left the taps (which he called faucets). He was vaguely aware that sewerage would be needed to cope with this flow and it occurred to me that he hoped his firm would be engaged to design a sewerage system. Much later, if funds are provided, new sewers might eradicate the flooding and mosquito-breeding derived from this extravagent flow of water.

b. Malfunctioning facilities are inevitable if O and M are neglected and it is important to remember that often the renovation of malfunctioning systems is cheaper and more effective than providing new systems.

ENGINEERS IN THE DECADE

Consequently most of the engineering work to achieve Decade objectives differs from that associated with conventional design and construction. In particular it tends to be samll in scale and to be concerned with what happens after a project is completed rather than before. I have previously likened this to pregnancy, suggesting that engineers like mothers should devote their attention to their baby after it is born - after the official opening of a project (reference 9).



It is commonly assumed that the professional qualities required for such work are at a low level. What rubbish! It is comparatively easy to design and build in the way which is familiar in Europe and North America. There are plenty of reference books; standards can be used to define the dimensions and quality of materials and components; the individual engineer often works in a team which includes specialists; expert advice is at hand; computers are available.

The field engineer in Decade programmes often has to work on his own with little support. If there is a telephone near it probably does not work. So the engineer's technology has to be so good that he can make good decisions without reference books, standards, other experts or computers.

Equally important is the engineer's ability to relate to people. In particular his own work must fit in with the needs, the aspirations, the interest of the people for whom he is working (reference 10). This brings us to consider the matter of motivation. Like everyone else, engineers have varied motivation. The forces motivating an individual engineer may include some of the following-

* pride in professional competence (and so a wish to demonstrate professional superiority).
* a search for innovation, to introduce things that have not been done before.
* a wish to construct - to see something permanent resulting from work done.
* the profit motive, which may be merely contractors or consultants' necessity to cover costs... but profit may expand so that it becomes -
* greed, seeking the maximum personal gain by fair means or foul.
* an altruistic desire to improve the lot of others who are less fortunate, which may be mixed with-
* a wish for high regard because of what has been done for those in need.

Motives actuating engineers are likely to be mixed. Other professionals may be motivated by similar ideas.

OTHER PROFESSIONALS IN THE DECADE

In several of the volumes written by the World Bank and their associates there is a diagram showing 'a recommended structure of feasibility studies for sanitation programme planning' (for example, references 11 and 12). Such feasibility studies are divided into six steps and tasks are divided between a sanitary engineer and public health specialist, an economist and a behavioural scientist. The community also contributes to the study. An interesting feature of this structure is that the engineer is involved in only three stages but both the economist and the behavioural scientist have work to do in four stages. The key stage (preparation of a short list of feasible alternatives) is the responsibility of the economist.

Nowadays lawyers, accountants and the like try to infiltrate themselves into all the top jobs, so it is not surprising that economists take such a prominent place in this diagram. there was much to be said for the old state-of-affairs when the engineer made all major decisions after taking advice from those concerned with legal and financial details, and also from geologists and other scientific experts.

In fact the diagram is over-simplified as well as being biased in favour of economists. Health, physical and environmental aspects are all lumped together. This package might reasonably include stages where advice is taken from geologists, groundwater hydrologists, chemists and bacteriologists. To cope with all the complexity of tropical deseases (reference 13) is itself a major undertaking.

If a similar diagram were to be drawn for implementation of sanitation or water supply programmes it should show the preponderance of work for community development staff and technologists. Community participation is essential for successful implementation and utilization of many programmes. This has been propounded so often that I will not go into it again, taking it as accepted that people must be involed. The problem is... how?

Social scientists working on water supply and sanitation programmes of the kind we are considering have two primary functions-

a. to study and work with communities who might benefit to find out what systems are most acceptable; and
b. to encourage such use of improved sanitation and water supply that benefits are realized and that the benefits continue to be available (because of appropriate operation and maintenance).

When considering acceptability, the study might also try to find out what is likely to influence a change of acceptability if systems which are socially acceptable are not at the same time technically acceptable. Technical acceptability here includes from a health point of view.

For example, a community might chose - and therefore show preferential acceptance of - a water source which is unacceptable from a health point of view because it is polluted.

In almost all situations, the social and community aspects of implementing Decade programmes are of tremendous importance for their success.

But...

Are technologists on the one, hand, and behavioural/social/ community/development people on the hand, capable of dealing with the difficulties of implementation? Does their education and training prepare them for this work?

To gain some clue to this, let us look at some aspects of education and training in Africa.

EDUCATION OF ENGINEERING GRADUATES

Professional engineers involved in water and sanitation commonly have a degree in civil engineering. Gecage (reference 14), himself a university lecturer, indicated engineering degree courses in Africa by writing 'the implicit objective of university courses seems to be the production of researchers. The appointment and promotion of staff is based on research criteria and it is almost impossible to appoint experienced engineers because they seldon have research qualifications'.

In addition, civil engineering is dominated by 'structures' and many courses provide no practical water engineering. In the few universities where public health engineering (or sanitary engineering) is included, the background of the lecturers is often research in some European or north American univeristy - usually research into some esoteric topic like 'nitrification in the activated sludge process' which is irrelevant to most of Africa. In Africa, masters' courses have recently started at a few universities but have had serious staffing problems.

EDUCATION IN THE SOCIAL SCIENCES

Those who eventually become professionally involved in human/ communal aspects of water supply and sanitation are graduates from a wide variety of courses in the general social sciences field. Some courses concentrate on community aspects or administration, some on development and others emphasize the personal psychological interactions of individuals. Technology finds no place in syllabi and the social works has to pick up scraps of technical information when already on the job.

Workers of this kind are often very successful in encouraging local people to embark on projects for water supply and sanitation. However, there is a terrible risk if no technical advice is obtained. I have previously referred to self-help projects which failed because of faulty technology (reference 9). Such failures not only waste the community resources and efforts; they can have an extremely damaging effect on the morale of the community.

It is therefore absolutely essential that community workers and the like who become involved in water supply and sanitation should have some technological training. Perhaps the first lesson to be learned is that simple technology is not as simple as it looks. Over-optimism about what can be achieved easily leads to frustration. At the very least these community workers should be aware of situations where expert engineering advice should be sought. At best they will learn techniques which can be passed on to communities they serve.

TRAINING OF TECHNOLOGICAL SUB-PROFESSIONALS

The titles given to sub-professionals vary considerably. A shortage of trained technicians in Africa is often mentioned as a major hindrance to effective progress in water supply and sanitation. It is seldom explained what is meant by 'technician'. In some places a technician does similar work to a professional engineer, but at a slightly lower level with more routine and less call for initiative. Surveyors, draughtsmen and laboratory analysts are often classified as technicians. Elsewhere a technician may be an artisan, like a pipe-fitter, mason or carpenter.

Without a detailed job description it is difficult to know what training is appropriate for a technical assistant, a field officer or a water inspector. Some sub-professionals work in departments headed by engineers but in many countries all pipeless systems for both rural water supply and sanitation come under the ministry of health, with medical doctors rather than engineers in charge. Titles of sub-professionals then include health aides, health assistants and others including the fashionable word environment.

In many parts of Africa the training of technicians is bedevilled by the same problem that besets universities - a quest by the staff for academic respectability. So a technical school tries to be a technical college, and a technical college wants to become a polytechnic or university. More and 'better' qualifications are offered with little regard for what the students will do when qualified. In the early days of independence much was spoken and written about the harm caused by the colonial examination system, but since then the influence of examinations on education has generally increased.

Fortunately some well-planned sandwich courses have been started. For example the training school in Kenya includes a pre-selection course after which water supply inspectors are given two years' field training followed by a refresher course and examination. those selected at the best students have four years' future training divided between work at the polytechnic and on the job (reference 15).

TRAINING OF AFRICAN CRAFTSMEN

Craftsmen such as carpenters and pipe-fitters are often entirely trained on the job. Squatter workshops thrive in most towns with two or three carpenters or motor mechanics working together in the open or under a crude shelter. True craftsmenship is often passed on to others in the informal sector (reference 16). Unfortunately some trade schools have failed to achieve the purpose for which they were set up. Due to striving after ever-higher standards these schools lead students to feel above their crafts so that they are willing to work only in a supervisory capacity.

THE NEED FOR COMMUNITY ENGINEERS

Training is only part of human resource development, as Carefoot (reference 17) has pointed out. Planning and management are equally important components of the effective use of manpower. At the professional level the Water Decade requires a variety of skills. We have critized the priority accorded to economists in feasibility studies and noted that for implementation both technology and sociology are essential. In some well-funded programmes, such as those supported by IDRC and the Bank in Botswana and Tanzania, the establishment does include professionals from both disciplines. This is unusual. A recent account of a massive village water supply programme in South Korea (reference 18) reported that 8874 pipelines had been installed. The programme called for 145 civil engineers, 337 sanitary engineers and 1450 technical assistants. No mention was made of any sociological input.

At the national or regional level where programmes are devised it may be possible to employ a variety of specialists - engineers, geologists, health experts, economists and behavioural scientists. but what is done - what should be done - at the local level? It is here that decisions must be made that largely determine whether a programme will be successful. For success, we remember again, the details as well as the overall plan must be both technologically and sociologically appropriate.

It is most unlikely in most African situations that two professionals will be available on the spot where details are decided. In any case, the difficulties of having more than one decision-maker are tremendous. What is needed is a single person who can decide what is best for a particular situation. How can this be achieved?

In the WEDC Group (water and waste engineering for developing countries) we believe that engineers should appreciate the sociological implications of their work. To use a chemical analogy, graduates of our MSc course at Loughborough should be tri-valent. They should be good technologists, good managers and good sociologists.

Also, we realize that the person-on-the-spot may not be an engineer or scientist. It may be someone whose primary function, background and training is in the social sciences such as community development. Consequently WEDC has a diploma course in community water supply and sanitation where non-technologists can study the whole tri-valent basis of decision making. WEDC also runs training programmes in developing countries and whenever possible these too include technology, management and sociology.

It is parhaps a pious hope, but it would be good if every undergraduate engineering course in Africa for those likely to be involved in water supply and sanitation were to include some sociological input. This would get a long way from the research-orientated couses criticized by Gecage. Happily there are already many signs of moves in the right direction.

Academics in several west African universities are devoting their energies to study of appropriate water supply and sanitation, as is shown by a number of conference papers (for example references 19-22). The next necessary step it to incorporate sociological studies in engineers' courses. Then "appropriate water supply and sanitation" will no longer be simply alternative forms of technology-centred engineering. They will be really appropriate for the purpose and circumstances, and especially for people and their needs (reference 23).

PEOPLE-CENTRED STUDIES FOR ENGINEERS AND SCIENTISTS

If asked to set out a syllabus for such studies I am inclined to reply that it does not much matter what is taught! The main requirement is that technologists should fully appreciate that people are important as engineering components in the provision of water supply and sanitation for rural areas and underprivileged urban communities in Africa. Consequently social studies should not be tacked on to a water engineering syllabus as an optional extra. The social aspect should be introduced at all possible stages and should be seen as equally important as any technological subject. A desire to help needy people is probably the strongest motivation for Decade work and also for learning how to do Decade work. Foremost among the social or human topics studies must be community participation.

In some literature on community participation a community is regarded as having its own specific habits, aspirations and viewpoint. However, in most places the interaction between different groups within a community has a significant effect on participation in water/sanitation programmes. Conflicting interests within the community may be associated with the place of women against that of men, or the young against the old. There may also be differences

* between the poor and the not-so-poor
* between those in paid employment and the self-employed or unemployed
* particularly in urban and peri-urban areas, between long-term residents and new migrants - and
* between people of different ethnic groups or sub-groups.

Added to these complexities are those associated with leadership patterns, which may be -

* traditional
* imposed by the government or the ruling political party
* derived from the personal qualities of those who take the lead, or
* derived from status due to age or wealth.

Another factor which is often forgotten is the tremendous variation within Africa. There are certain common traits throughout the continent, just as there are common problems and common characteristics throughout the third world. Throughout Africa there is a steady increase in the total population and and even greater increase in the urban population.

This inevitably has a major effect upon the provision of water and sanitation. But the pattern of urbanization, the special distribution of population and many other aspects of towns and cities vary greatly. They need to be studies to ensure that services are appropriate. Each urban centre has its own characteristics, as can be realized by comparing -

* the traditional Yoruba centres of south-west Nigeria (of which Ibadan is best known) where most of the population are Yorubas
* the colonial cities of the east, like Nairobi, Harare and Lusaka
* mining towns throughout the continent where the earliest housing was provided as bachelor quarters by the mining companies - and
* new capital cities like Gabarone in Botswana, Lilongwe in Malawi, Dodoma in Tanzania and Abuja in Nigeria. O'Connor (reference 24) presents a well-documented discussion of variations in African cities.

IN CONCLUSION

The provision of good water and sanitation to those who lack it requires an input of technological, socilogical and managerial skills. At the working level where programmes are implemented, it is unrealistic to expect to have separate people to deal with these different aspects. Consequently engineers should be so trained that they put people as high in their priorities as technology. At the same time there is a need for involved social scientists to appreciate the technological difficulties and solutions in implementing Decade programmes.

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NOTES ON AN ILLUSTRATED TALK

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The Blair Research Laboratory of the Ministry of Health in Zimbabwe has been promoting ventilated pit latrines since 1974 and large numbers have been built in the rural areas. More permanent and upgradeable ventilated latrines (Blair latrines as they are known in Zimbabwe) may find a place in peri-urban development plans in the future as the cost of conventional sewerage increases.

Before 1980, the standard Blair latrine was built with a large asbestos ventilation pipe and a ferrocement structure and roof. A spiral doorless structure was chosen as this offered privacy and guaranteed some darkness. Most of the properties of the Blair latrine had been worked out by 1975, although more has been learned since 1980.

This latrine system has been designed to work without water and is particularly useful where water is scarce or difficult to pipe to water-borne sanitary devices or in situations were there is no guarantee that water will be carried regularly to the installations.

The system offers protection against flies and odours on a conventional pit latrine without the use of water. The ventilated pit latrine which incorporates an efficient ventilation pipe fitted with a corrosion resistant flyscreen, substantially reduces the smell and fly problems.

How the latrine works

When the ventilation pipe is fitted to a latrine slab over a sealed pit it will draw air down the squatting aperture into the pit, with the odours passing up the ventilation pipe. Thus the foul air in the pit will not escape into the latrine itself. It has an additional advantage that most of the flies from the bush are attracted to the top of the pipe where the odours escape. Since the top of the pipe is fitted with a flyscreen, the flies are denied access via this route.

If flies do gain access to the pit by the squatting apeture and breed there, they are attracted towards light as they try to escape from the pit. If the latrine structure is dark enough within, sufficient light will go down the pipe. The flyscreen on the pipe will trap the flies and prevent them from escaping.

The vent pipe, which is an essential component of the system, has three functions. It draws odours out, leaving the latrine itself almost odourless; it prevents much of the fly breeding in the pit and it traps most of the flies that breed in the pit.

Structure variation

Since independance in 1980, a large range of structural designs have been tried. These range form ultra-low cost models made of wooden logs and mud, with a split reed pipe, to permanent brick structures. Mass produced commercial Blair latrines are also available.

How it is built

The most popular model for rural programmes is an all brick structure including the pipe. This is built over a round pit dug at least 3m deep and lined with bricks or heavy mortar. The bottom is left unlined.

A concrete slab is made and placed over a brick collar mounted at the head of the pit. Most Blair latrines built mowadays are offset from the pit, with much of the weight of the superstructure being taken by the solid ground to the side of the pit. This modification helps to reduce the chance of pit collapse. Both spiral and square shape doorless structures are advocated, the latter is becoming more popular since it offers more room internally for washing.

The habit of body washing is encouraged in latrines, indeed it is felt that this dual role of the cubicle (washroom plus latrine) may be reason why the latrine has proved so popular in Zimbabwe. In rural programmes, a pvc coated glass-fibre screen has been used at the head of the pipe. This screen has a life of approximately five years in Zimbabwe, if it is well mounted on a pipe; after this period it requires replacement.

The regular inspection of screens form part of the maintenance schedule of Blair latrines in Zimbabwe. Stainless steel screens are preferred however, as these offer more permanence. Preferably two latrines should be built on a large plot (male and female) or a single brick structure with two separate pits and compartments.

Life of pit

Latrines are designed to last between ten and 15 years if paper is used for anal cleaning and the slab is washed down regularly with water. An accumulation rate of approximately 0.02cu m per person per year has been calculated for pits used by medium size families under ideal conditions. Clearly this figure is raised if the pit is also used for garbage disposal and solid objects are thrown down the pit.

In rural development programmes latrines are promoted on a family basis and the family is provided with certain basic components (particularly those not available locally) to help them build the latrine.

Very often this consists of a few packets of cement and pvc ventilation pipe (if burnt bricks are not available). If a brick ventilation pipe is used, the screen is also supplied. In every case the family contributes the greater part of the materials particularly those that are available locally. The user contributes even more in terms of labour. Health personnel play only an advisory role. This latrine system owes its success in many development programmes to its simplicity and flexibility.

Upgradeability

In more permanent peri-urban development areas, the Blair latrine has been upgraded so that it incorporates a standard pvc vent pipe fitted with a stainless steel screen, a permanent well-built brick structure and a heavily mortared tank beneath ground level. The tank is fitted with an effluent discharge pipe, much like the one used in septic tanks. In this case the tank fills with fluids and washing water and excess overflows through the effluent discharge pipe into a soakaway.

There are a number of advantages to this system which has been tried on a small scale in Zimbabwe since 1977. First and foremost, experience has shown that latrines of this type are relatively easy to empty, the tank contents being relatively liquid. The use of a locally made Bumi diaphram hand pump permits the emptying of the tank, although a vacuum tanker would do the same on a large scale.

The fact that the tank can be emptied makes the structure as a whole defineable as permanent. Secondly it is possible to upgrade the latrine at a later stage and fit waterborne sanitation units. This has also been demonstrated in Zimbabwe - flush latrines, both the squat pan and pedestal type have been added with success to Blair latrines. The term VIP is rarely used in Zimbabwe since ventilated latrines are not necessarily built over pits.

Multicompartment Blair latrines have also been designed for schools, some with tanks and some with brick lined pits.

In some cases, flush latrines are fitted to two of a series of tanks - in a series of ten - two being flush and the rest being standard tank version of the Blair latrine. These can all be fitted to a common small bore sewer of 50mm or 75mm capacity leading into a common soakaway.

Motivation

Blair latrines have been actively promoted through films, radio and television, pamphlet distribution and demonstrations for many years. Demonstrations set in strategic points have proved to be by far most effective.

The latrine appears in the curricula of both primary and secondary school education. It is a system that has been proved to work over many years, and development schemes involving its construction continue accelerate.