# THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY IN THE UNITED REPUBLIC OF TANZANIA

## FINAL REPORT
## VOLUME 1 : SUMMARY

JULY 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

# THE STUDY
# ON
# REHABILITATION OF
# DAR ES SALAAM WATER SUPPLY
# IN
# THE UNITED REPUBLIC OF TANZANIA

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## JAPAN INTERNATIONAL COOPERATION AGENCY

PREFACE

In response to a request from the Government of the United Republic of Tanzania, the Government of Japan decided to conduct a study on the rehabilitation of Dar es Salaam water supply and entrusted the study to the Japan International Cooperation Agency (JICA).

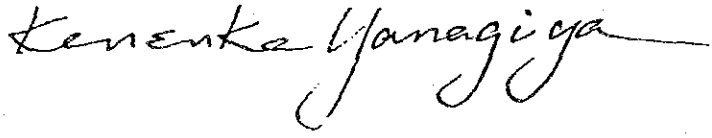
JICA sent to Tanzania a study team headed by Mr. Heiichiro Makino, Tokyo Engineering Consultants Co. Ltd., 3 times between November 1989 and March 1991.

The team held discussions with the officials concerned of the Government of Tanzania, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the United Republic of Tanzania for their close cooperation extended to the team.

July, 1991



Kensuke Yanagiya
President
Japan International Cooperation Agency

THE STUDY
ON
REHABILITATION OF DAR ES SALAAM WATER SUPPLY
IN THE UNITED REPUBLIC OF TANZANIA

July, 1991

Mr.Kensuke YANAGIYA
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

It is our pleasure to submit herewith the Final Report of "THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY IN THE UNITED REPUBLIC OF TANZANIA".

This report has been prepared by the Study Team in accordance with the contract signed on 9 November 1989, 20 June 1990 and 31 May 1991 between the Japan International Cooperation Agency and the Joint Venture of Tokyo Engineering Consultants and Pacific Consultants International.

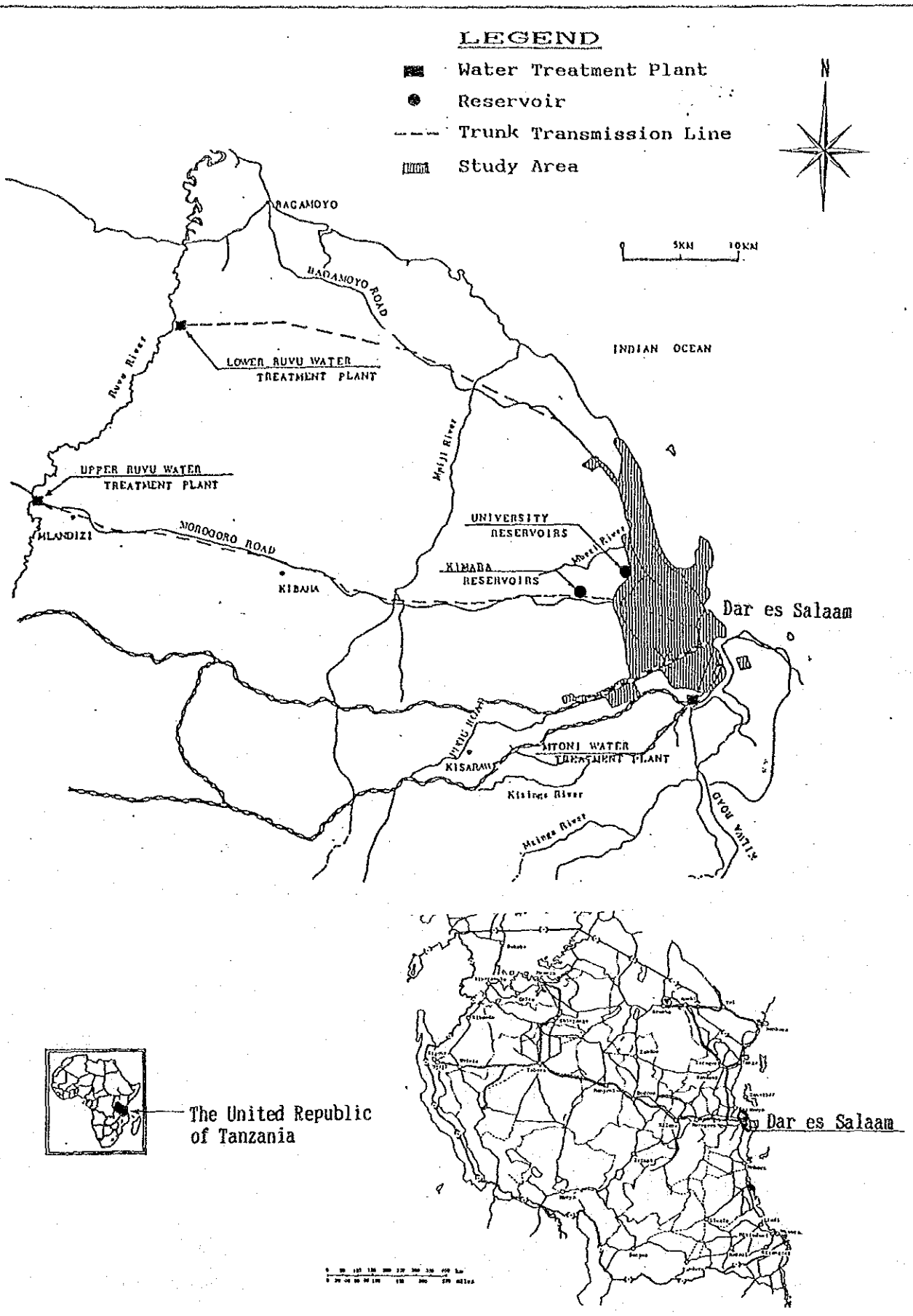
The report consists of Summary, Main Report, Supporting Report and Data Book. The Summary provides the summary of the Study and recommendations. The Main Report describes the results of the study and analysis. The Supporting Report contains the details of various studies. In addition, a Data Book has been prepared and submitted herewith.

Finally, we take this opportunity to express our sincere gratitude to Japan International Cooperation Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Health and Welfare, and Embassy of Japan in Tanzania, and also to officials concerned of the Government of the United Republic of Tanzania which gave useful advice to the Study Team during the study period.

Respectfully yours,

H. Makino

Heiichiro Makino
Team Leader




LOCATION MAP OF THE PROJECT

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

# CONCLUSION AND RECOMMENDATION

## CONCLUSION

1. The water supply system of Dar es Salaam is in very bad condition - insufficient water supply, low pressure, deteriorated facilities, leakage from pipelines - and rehabilitation is urgently required.

2. The basic approach in the rehabilitation plan is to utilize the existing facilities to the maximum and to enhance the utility of such facilities. At the same time, it is aimed to enable the parastatal organization charged with water supply, NUWA, to become self-reliant and capable of sustainable development on its own resources.

3. With the exception of the Upper Ruvu system which has been rehabilitated recently and which is out of scope of this Study, all facilities of the city's water supply system are to be rehabilitated by 1995. The work will involve contractual works for repairs to a part of the water treatment works at Lower Ruvu and Mtoni, leakage control along the transmission and distribution pipelines, connection of existing pipes, laying of new primary and secondary pipes and creation of a middle water pressure zone. Further, it will also involve leakage control measures, mapping, pipe cleaning, meter installation, collection of arrears and recovery from illegal connections.
   The underground leakage prevention project to be conducted in-house by NUWA will be a long-term project and will produce many intangible benefits also, depending on the efforts expended into it, and based on this, contractual works for increase of water pressure should be undertaken.

4. The project should result in 80 % of the population, i.e., 1.2 million people, benefiting from improved supply, with the increase in the per capita water supply being of the order of 27 liters per day.

5. The cost breakdown of the rehabilitation project for the target year of 1995 is as follows :

(Unit : T.Shs. million)

| | Contractual Works | In-House Works | Total |
|---|---|---|---|
| Foreign Currency | 3,297 | 2,237 | 5,535 |
| Local Currency | 1,757 | 388 | 2,146 |
| Total | 5,054 | 2,625 | 7,680 |

(Total values may not match due to rounding-off)

6. Financial resources to cover the capital and operations and maintenance costs for this project will come from water charges and recovery of money from bad debts and illegal connections. In the

short-term, even if the identification of all illegal connections and full recovery of payment arrears is accomplished, obtaining hard loans is almost impossible. However, even if 70 % of the above is accomplished, there is the possibility of obtaining soft loans. Further, if 60 % of the above is accomplished, it will become possible to obtain financial assistance from the government. Therefore, NUWA should make all efforts to ensure that the above targets are met.

7. In order for NUWA to balance its books, it will be required to revise the water tariff annually, with the increase required in the case of the rehabilitation project not being done at 32 % and in the case of the rehabilitation project being done at 20 %. The corresponding nominal inflation rate is expected to be 30 %, which is greater than the lowest salary increase rate of 17 %.

8. NUWA employees should be motivated by means of incentives, and the salaries of lower paid employees should be raised and a productivity-linked bonus scheme should be initiated. Towards this end, a task force should be established to go into the matter and action taken at the earliest.

9. The agency responsible for implementation of these measures will be NUWA. For this project, the personnel requirements are - 7 engineers, 140 technicians, 8 surveyors/draftsmen, 26 drivers, 19 crane operators. NUWA will have to arrange for transfers within the organization, training and recruitment of new employees.

**RECOMMENDATION**

1. Even if this rehabilitation project will be completely implemented, there will be a major demand-supply imbalance by the year 2000. To counter this, it is required that a long-term water supply expansion plan be drawn up, up to the year 2020, for which implementation should start by 2000.
2. The water resource capacity expansion of Mtoni should be based on the overall water resource development of the Ruvu river.

3. The manpower requirements as well as the requisite training for the leakage prevention project should be taken care of.

4. The indigenous production of alum and other chemical coagulants should be achieved.

## TABLE SELECTED PROJECT

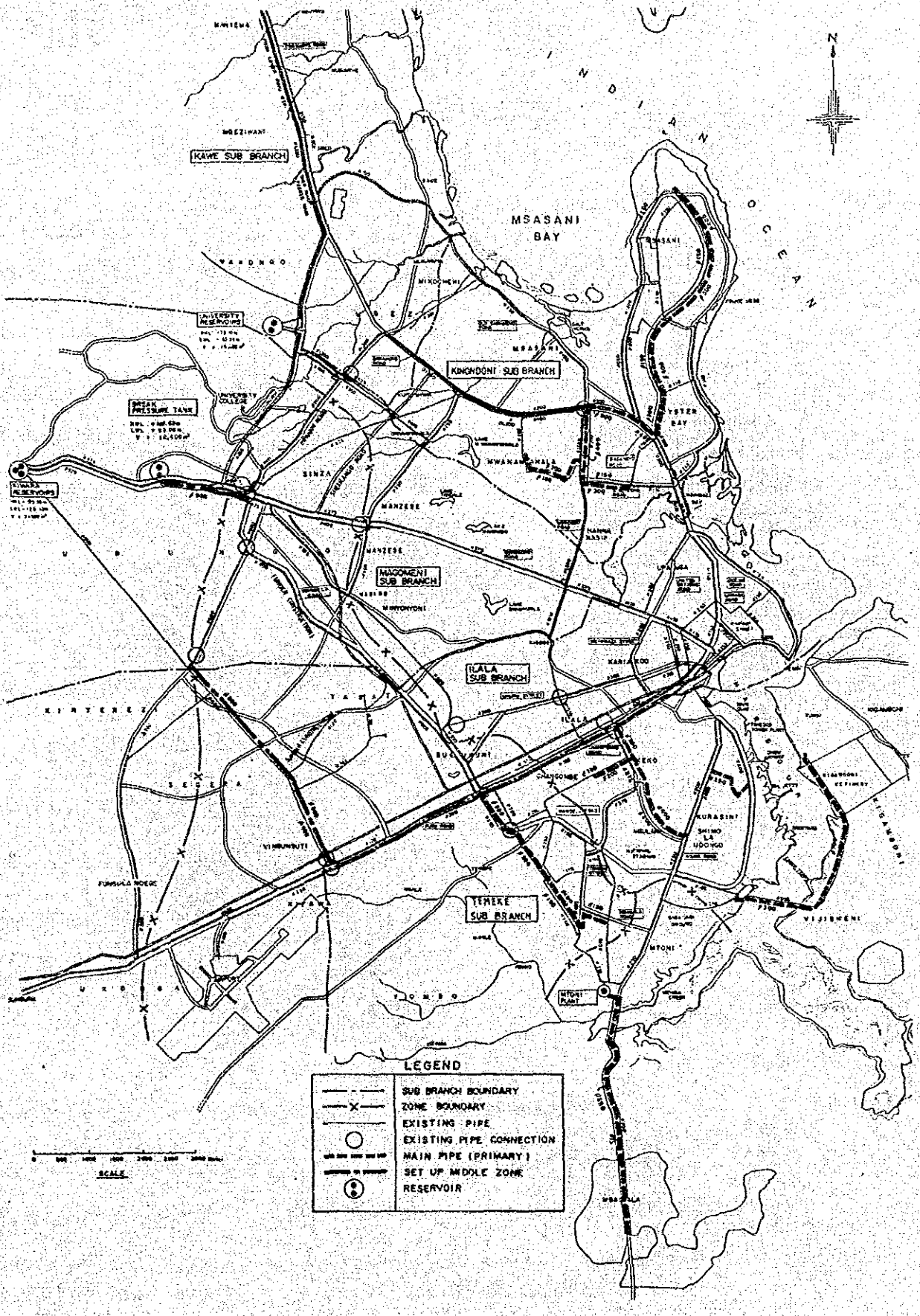
| Works Description | Unit | Quantity |
|---|---|---|
| **A.IN-HOUSE ACTIVITY (continuous work items)** | | |
| j) Meter installation | each | 15,000 |
| b) Leakage control measure in the distribution system | lump sum | 1 |
| (including mapping system) | lump sum | 1 |
| f) Pipe cleansing | | |
| 1 Air scouring | meter | 417,000 |
| 2 Scraping & lining | meter | 213,000 |
| **B.CONTRACTUAL WORK (non-continuous work items)** | | |
| a) Leakage control measure (transmission system) | | |
| 1 Replace pressure reducing valve | each | 16 |
| 2 Replace meter in off-takes | each | 16 |
| b) Leakage control measure (distribution system) | | |
| replace service pipe with distribution pipe | meter | 90,000 |
| c) Existing pipe connection | each | 14 |
| d) Main pipe laying (primary) | | |
| 1 Supply and lay pipe (kinondoni, 400 - 200 mm ) | meter | 4,600 |
| 2 Supply and lay pipe (msasani, 500 - 200 mm) | meter | 6,700 |
| 3 Supply and lay pipe (temeke, 500 - 400 mm) | meter | 4,300 |
| 4 Supply and lay pipe (kurasini, 500 -200 mm) | meter | 4,800 |
| 5 Supply and lay pipe (kigamboni, 300 mm) | meter | 5,100 |
| 6 Supply and lay pipe (mbagala, 250 mm) | meter | 5,100 |
| e) Main pipe laying (secondary) | | |
| 1 Supply and lay pipe at mbezi | meter | 14,300 |
| 2 Supply and lay pipe at tabata | meter | 9,300 |
| 3 Supply and lay pipe at ukonga | meter | 4,400 |
| 4 Supply and lay pipe at yombo | meter | 8,300 |
| 5 Supply and lay pipe at kigamboni | meter | 10,500 |
| g) Middle zone | | |
| 1 Break pressure tank | $m^3$ | 10,600 |
| 2 Supply and lay pipe at ubungo | meter | 2,800 |
| 3 Supply and lay pipe at vingunguti | meter | 5,000 |
| h) Treatment plant | | |
| 1 Lower ruvu treatment plant | | |
| S & I water level sensor,sludge pipe,chlorinator pipe | lump sum | 1 |
| 2 Mtoni treatment plant | | |
| Repair coagulation basin, alum dosing equipment, | lump sum | 1 |
| soda ash dosing equipment,disinfection equipment | lump sum | |

## TABLE DISBURSEMENT SCHEDULE

(Unit: T.Shs.million)

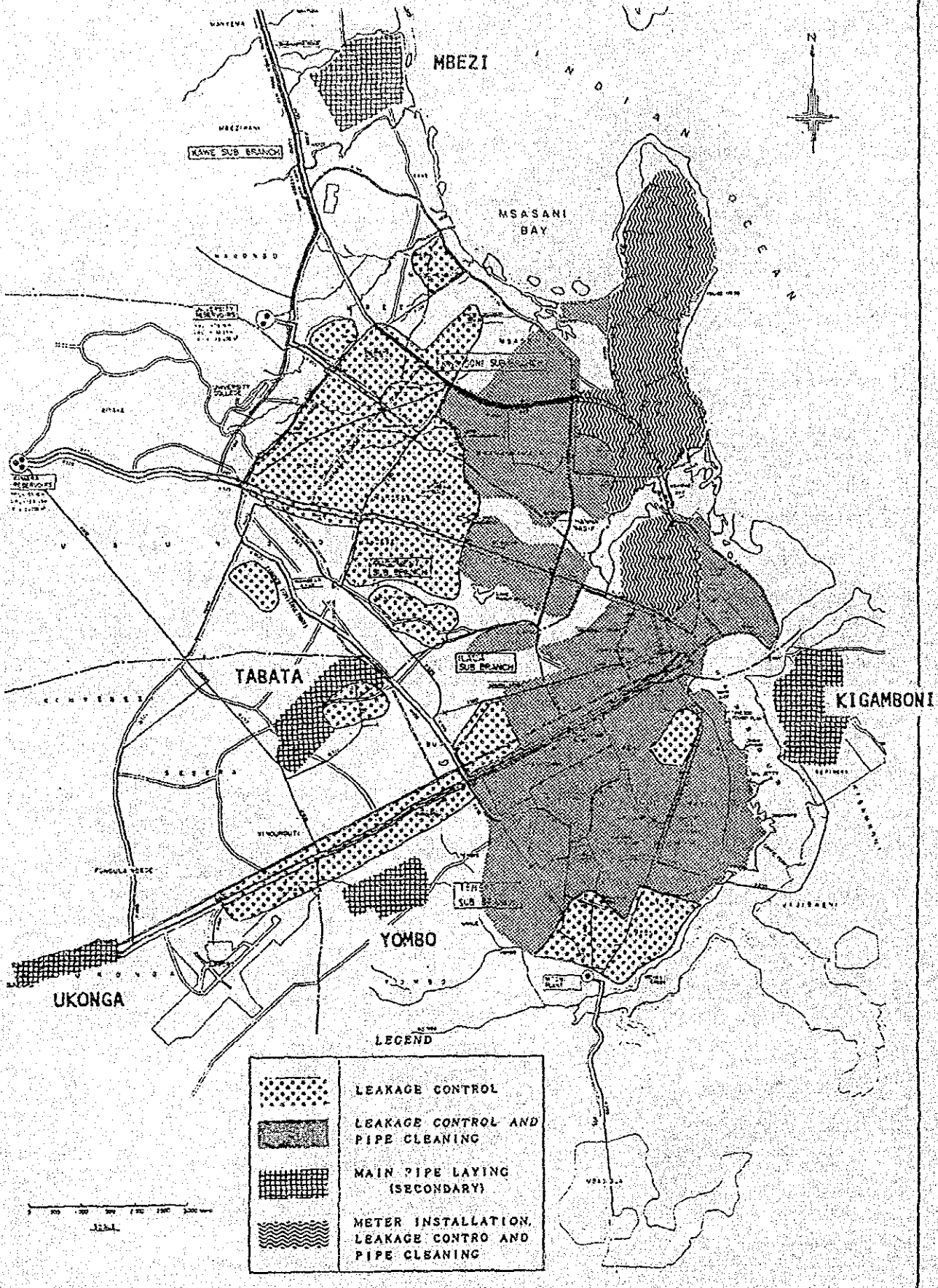
| Measures | TOTAL | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|
| A.IN-HOUSE WORKS (CONTINUOUS WORKS) | | | | | | |
| 1) METERING SYSTEM | 538 | 277 | 253 | 3 | 3 | 3 |
| 2)-1 LEAKAGE CONTROL MEASURE(DISTRIBUTION SYSTEM) | 1,254 | 397 | 275 | 252 | 184 | 145 |
| 2)-2 MAPPING SYSTEM | 12 | 6 | 2 | 2 | 2 | 2 |
| SUB TOTAL | 1,266 | 403 | 277 | 254 | 186 | 147 |
| 3) PIPE CLEANING | 699 | 424 | 69 | 69 | 69 | 69 |
| 4) ARREARS AND ILLEGAL CONNECTION | 123 | 25 | 25 | 25 | 25 | 25 |
| SUB-TOTAL (IN-HOUSE ACTIVITY) | 2,625 | 1,129 | 622 | 350 | 281 | 243 |
| B.CONTRACTUAL WORKS (NON-CONTINUOUS WORKS) | | | | | | |
| 1) LEAKAGE CONTROL MEASURE (TRANSMISSION LINE) | | | | | | |
| 1 Replace pressure reducing valve | 33 | 33 | | | | |
| 2 Replace meter in off-takes | 10 | 10 | | | | |
| 2) LEAKAGE CONTROL MEASURE (DISTRIBUTION SYSTEM) | | | | | | |
| Replace service pipe with distribution pipe | 612 | | | | | 612 |
| 3) EXISTING PIPE CONNECTION | 296 | 296 | | | | |
| 4) MAIN PIPE LAYING (PRIMARY) | | | | | | |
| 1 Supply and Lay Pipe at Kinondoni | 229 | | 229 | | | |
| 2 Supply and Lay Pipe at Msasani | 426 | | 426 | | | |
| 3 Supply and Lay Pipe at Temeke | 380 | | | 380 | | |
| 4 Supply and Lay Pipe at Kurasini | 326 | | | 326 | | |
| 5 Supply and Lay Pipe at Kigamboni | 255 | | | 255 | | |
| 6 Supply and Lay Pipe at Mbagala | 214 | | | 214 | | |
| SUB TOTAL | 1,830 | | 655 | 1,175 | | |
| 5) MAIN PIPE LAYING (SECONDARY) | | | | | | |
| 1 Supply and Lay Pipe at Mbezi | 112 | | | | 112 | |
| 2 Supply and Lay Pipe at Tabata | 72 | | | | 72 | |
| 3 Supply and Lay Pipe at Ukonga | 34 | | | | 34 | |
| 4 Supply and Lay Pipe at Yombo | 66 | | | | 66 | |
| 5 Supply and Lay Pipe at Kigamboni | 82 | | | | 82 | |
| SUB TOTAL | 366 | | | | 366 | |
| 6) MIDDLE ZONE | | | | | | |
| 1 Break pressure tank | 654 | | | | | 654 |
| 2 Supply and Lay Pipe at Ubungo | 684 | | | | | 684 |
| 3 Supply and Lay Pipe at Vingunguti | 510 | | | | | 510 |
| SUB TOTAL | 1,848 | | | | | 1,848 |
| 7) TREATMENT PLANT | | | | | | |
| 1 LOWER RUVU TREATMENT PLANT | | | | | | |
| 2 MTONI TREATMENT PLANT | | | | | | |
| SUB TOTAL | 59 | 59 | | .. | .. | |
| SUB-TOTAL (CONTRACTUAL WORK) | 5,054 | 398 | 655 | 1,175 | 366 | 2,460 |
| TOTAL | 7,680 | 1,526 | 1,280 | 1,526 | 648 | 2,704 |
| PHYSICAL CONTINGENCY | 1,151 | 229 | 191 | 229 | 97 | 405 |
| PRICE CONTINGENCY | 5,606 | 132 | 288 | 631 | 775 | 3,780 |
| GRAND TOTAL | 14,436 | 1,888 | 1,756 | 2,384 | 1,519 | 6,888 |

(1 US$ = T.Shs.200 = Japanese Yen 140, at November,1990)



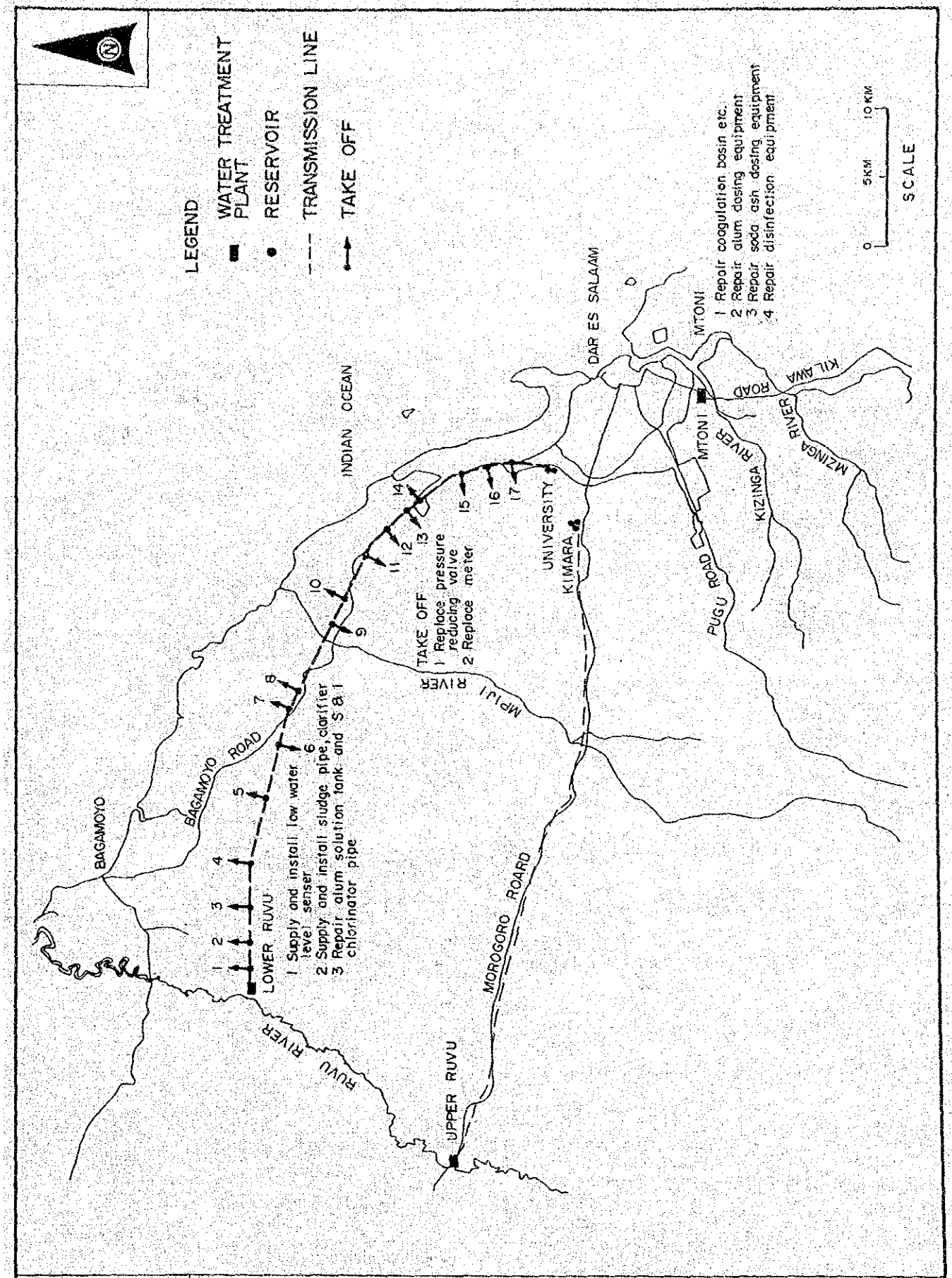

PROPOSED REHABILITATION PROJECT
- DISTRIBUTION SYSTEM (PRIMARY) -

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY




PROPOSED REHABILITATION PROJECT
- DISTRIBUTION SYSTEM (SECONDARY) -

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY




PROPOSED REHABILITATION PROJECT
- TREATMENT PLANT AND TRANSMISSION LINE -

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

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# 1 INTRODUCTION

## 1.1 BACKGROUND OF THE STUDY

In 1988, the Government of the United Republic of Tanzania (GOT) requested the Government of Japan to conduct a Study on the Rehabilitation of the Dar es Salaam Water Supply System (henceforth referred to as "the study"). The Government of Japan, in response to the official request of the GOT, decided to carry out the study and Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of technical cooperation programmes of the Government of Japan, undertook the Study, in close cooperation with the concerned authorities of the GOT.

In June 1989, JICA dispatched a mission to Tanzania to do a preliminary study, as well as hold discussions on the scope of work of the Study. The scope of work was agreed upon between the GOT and the JICA mission on June 7, 1989. Based on the scope of work, the National Urban Water Authority (NUWA) would act as the counterpart agency to the Japanese study team organized by JICA. Tokyo Engineering Consultants Co. Ltd., in association with Pacific Consultants International, was selected by JICA for conducting the Study.

## 1.2 OBJECTIVE OF THE STUDY

1) to prepare an improvement plan for strengthening NUWA's management and operation aspects so as to ensure sustainable development of NUWA.
2) to identify the scope and the size of the rehabilitation of the existing water supply system aimed at provision of a sufficient and steady water supply throughout the service area and to formulate a timely and orderly implementation schedule of the overall rehabilitation.
3) to prepare a preliminary design of the immediate rehabilitation work proposed above, together with cost estimates and to verify viability of the rehabilitation from a cost-benefit point of view.

## 1.3 SCOPE OF THE STUDY

The Study covers the water supply system for the city of Dar es Salaam (DSM), excluding the areas along the transmission pipelines.

In order to achieve the objectives mentioned above, the study has covered the following items:

1. Data collection and review
   (1) Socio-economic and natural condition
   (2) On going water supply and other relevant projects
   (3) Water supply and other related plans

2. Study on the existing water supply system
   (1) Design criteria
   (2) Structure, capacity and performance of water supply facilities
3. Study on institutional, management and financial condition
   (1) Institutional
   (2) Management
   (3) Financial condition
4. Study on water treatment plant rehabilitation plan
   (1) Intake facilities
   (2) Treatment facilities
   (3) Water quality
5. Study on the distribution system rehabilitation plan
   (1) Distribution pump and reservoir
   (2) Distribution pipe
6. Study of the service system rehabilitation plan
   (1) Service pipe
   (2) Water meter
7. Study on cost recovery strategy
   (1) Water charge collection system
   (2) Financial plan
8. Formulation of maintenance plan
   (1) Management
   (2) Water treatment plant
   (3) Distribution system
   (4) Service system
   (5) Leakage prevention strategy
   (6) Repair-shop
9. Formulation of training plan
   (1) Overall training program
10. Formulation of rehabilitation plan
   (1) Identification of scope and size of rehabilitation
   (2) Formulation of implementation schedule
   (3) Identification of high priority projects
11. Preliminary design of immediately required rehabilitation work
   (1) Preliminary engineering design
   (2) Cost estimation
   (3) Financial evaluation

## 1.4 UNDERTAKING OF THE STUDY

The Government of Japan, through JICA, has taken necessary measures to dispatch the study team to GOT and effect technology transfer to the GOT counterpart personnel in the course of the Study. The study team commenced the work at the end of November 1989 and from the beginning of December, undertook surveys, discussions with GOT authorities concerned, field investigations, and analyses of data collected in Dar es salaam until end of March, 1990. The results of the activities are presented in the Progress Report (1), which was submitted to NUWA in March 1990.

The second on-site survey was conducted from the end of June to the end of December 1990. The results of the study of the existing water supply system and a rehabilitation plan was presented in the Progress Report (2), which was submitted to NUWA in October 1990. The Interim Report, which contains rehabilitation works and improvement programmes required, was submitted to NUWA in November 1990. The Draft Final Report, which contains all the study items, was submitted to NUWA in March 1991, and discussions on the report were held in DSM in March 1991. The Final Report was completed in June 1991, reflecting conclusions from the discussions.

## 1.5 REPORTS AND DOCUMENTS PREPARED

A number of reports have been prepared and submitted to NUWA during the period of the Study, in the form of progress or interim and draft reports, covering all the work performed under the Study. All reports culminate in the Final Report, which is composed of the following four volumes.

(1) Volume One SUMMARY REPORT
(2) Volume Two MAIN REPORT
(3) Volume Three SUPPORTING REPORT
(4) Volume Four DATA

# 2 GENERAL CONDITIONS

## 2.1 NATURAL CONDITIONS

DSM is the largest city in Tanzania, with a population of approximately 1,360,000 in 1988, and is politically, economically and culturally the national centre. It is situated on the eastern coast of Africa at a latitude of 6° 45' south and a longitude of 39° 18' east. Inland from the coast lies the coastal plains, bordering the Pugu Hills, which rise up to an altitude of 200 meters.

The temperature in the city is usually high, ranging between 17 and 32 °C, with humidity between 50%

and 90%. The main winds are the monsoons blowing to and from the Indian Ocean. The bulk of the rain falls between March and May, but continued showers throughout the year are common. The total rainfall per year is between 1,000 and 1,400 mm.

## 2.2 SOCIO-ECONOMIC CONDITIONS

Since 1961, when Tanzania became independent, the GOT has been making efforts to achieve self-reliance. In June 1982, the GOT adopted a 3-year comprehensive structural adjustment programme to address the country's structural problems and to rehabilitate the country. The economic recovery program (1986/87 to 1988/89) represents a continuation of the structural adjustment effort. The emphasis of the programme is to channel resources to raise the productivity in agriculture because of its importance to the economy.

Over the years, the pressure on available resources has made it difficult for the GOT to allocate sufficient resources to maintain the social and physical infrastructure created in the previous two and a half decades. Consequently, water supply systems, roads, railways, schools and hospitals now require substantial rehabilitation, for which external assistance is being sought.

Real per capita income, as measured by GDP at fixed 1976 prices, fell steadily as population growth outpaced the increase in GDP; in 1984, it was estimated at $240, 17% less than in 1980.

The share of water supply expenditure to total economic service was about 10% and the portion of development of which has been increasing about 40% to 60% from 1985/86 to 1988/89.

Tanzanian socialism, i.e. creation of egalitarian village communities, decentralization, and self-reliance proclaimed by the Arusha Declaration in 1967, guides politics and government, which has been controlled by the Revolution Party (CCM).

As the GOT has now accepted the loan terms set by the IMF, i.e. introduction of market economy, turmoil prevails in the economy when these two principles collide with each other. The change is also sharply felt in the social service sector, like water supply. The conflict notwithstanding, its effort to improve human resources is clearly visible, while political targets are somewhat blurred.

## 2.3 WATER DEMAND

In DSM, the population and the urbanized areas has increased rapidly in recent years. In 1946, it was 45,000 and in 1957, it had risen to 128,000, with an average annual growth rate of 10 percent. At almost the same growth rate, the population had risen to 356,000 in 1967. Since then, the annual

growth rate has decreased as shown below and in the census results released in 1988, the population was 1,360,850. Greater DSM encompasses an area of 1,393 km².

**POPULATION AND ITS GROWTH RATE**

| POPULATION | 1967 | 1978 | 1988 |
|---|---|---|---|
| Dar es Salaam | 356,286 | 843,090 | 1,360,850 |
| Tanzania | 12,313,469 | 17,512,610 | 23,174,336 |

ANNUAL AVERAGE GROWTH RATE (% per annum)

| | 1967-78 | 1978-88 |
|---|---|---|
| Dar es Salaam | 7.8 | 4.8 |
| Tanzania | 3.2 | 2.8 |

The total consumption is 144,429 m³/day in 1990, of which, 128,180 m³/day for domestic; 4,612 m³/day for industrial; 6,282 m³/day for commercial and 5,355 m³/day for institutional.

The overall current suppression factor for DSM is estimated as 87%, signifying that in 1990, insufficient water pressure causes the water consumption to drop 13% from what would normally be consumed has insufficient water pressure not been a constraining factor. It is noted that 87% is a value on a daily average basis. The water supply and demand/consumption balance for DSM is as given in Table. From this, it can be seen that the overall leakage within the NUWA distribution system is 35%.

**WATER SUPPLY AND DEMAND BALANCE (1990, DAILY AVERAGE BASE)**

| | | |
|---|---|---|
| (A) Gross Supply: | | 296,300 m³/day |
| (Lower Ruvu Treatment Plant) | 207,500 m³/day * | |
| (Upper Ruvu Treatment Plant) | 82,000 m³/day | |
| (Mtoni Treatment Plant) | 6,800 m³/day | |
| (B) Net Supply: | | 193,400 m³/day |
| (C) Leakage Ratio: | | 35 % |
| (D) Unsuppressed Consumption | | 144,429 m³/day |
| (E) Unsuppressed Demand: (D)/{1-(C)} | | 222,200 m³/day |
| (F) Overall Suppression Factor: (B)/(E) | | 87 % |

(source: JICA Study Team) Note: Difference between gross supply and net supply is consumed or leaked out along the transmission lines. Demand = consumption + leakage * Lower Ruvu plant is overproducing than the rated capacity.

## 2.4 SUPPLY TO THE CITY

The chief source of water for DSM is the Ruvu river flowing northwards on the west of the city towards the Indian ocean. The supply is supplemented, to a small extent, by tapping water from the Kizinga river at Mtoni, which started operations from 1933.

Water is drawn at two different intakes in the Ruvu river, located 20 kilometers apart. The older intake,

for the Upper Ruvu System, is located at about 65 km west of the city, along the Morogoro road. The second intake, for the Lower Ruvu System, is located near Bagamoyo town, downstream of the older one and about 18 km upstream from the mouth of the river. The total installed capacity of the three water plants is 270,800 $m^3$/day (59.5 mgd). The Upper Ruvu system has started the operation from 1959 and the Lower Ruvu system from 1976.

However, the design capacities have never been attained in practice, particularly in the case of the Upper Ruvu system (which has been rehabilitated and whose output has reached the installed capacity at the end of 1990). The Mtoni system, which resumed operation in August 1989, again stopped operation in February 1990. Thus the current production capacity is 234,000 $m^3$/ day (51.4 mgd).

Two-thirds of the water delivered by the Upper Ruvu system and between 10 and 20% of that delivered by the Lower Ruvu system are consumed or lost to leakage along the transmission mains before reaching the reservoirs in the city. As a result, water available to the city at present is approximately 181,000 $m^3$/day (40 mgd), i.e., two-thirds of the design capacity.

## 3 ORGANIZATION AND FINANCE OF NUWA

### 3.1 PRESENT ORGANIZATIONAL CONDITIONS

#### (1) LEGISLATIVE AND LEGAL CONSIDERATIONS

The administrative structure at the national level changed with the promulgation of the Urban Water Supply Act, No.7 in 1981 when NUWA was established as a parastatal organization to manage all urban areas' water supply systems, responsible to the Ministry of Water, Energy & Minerals.

The Authority took over all the activities of the DSM Water Supply Corporation Sole which was placed under the City Council of DSM from 1977 and all the assets and liabilities of the latter were taken over by the former on 1st October 1984. On that date, the DSM branch (DSMB) of NUWA was formed in order to discharge its responsibility as the exclusive caretaker of the water supply system for the city of greater DSM.

#### (2) STRUCTURE OF THE DAR ES SALAAM BRANCH

1) NUWA HEADQUARTERS

The Board of Directors consists of a Chairman, a Director-General, two officials from the Ministry of Water, Energy and Mineral, six members from the concerned ministries, the Tanzanian Electricity Supply Co. Ltd., and four more members - one of whom is a director of city council, DSM. The Director-General of NUWA is responsible to the Board, which supervises the overall activities of NUWA.

There are four directorates - Operations, Project Planning & Implementation, Manpower Development & Administration, and Finance, which are all under its charge. The total staff number is 60.

2) DAR ES SALAAM BRANCH (DSMB)

DSMB is under the Operations directorates and responsible for the three treatment plants, two reservoirs, five sub-branch offices and six payment counters.

The branch manager is the chief administrative officer of the branch. The branch consists of four departments - Personnel & Administration, Operations, Finance and Project.

The number of staff members of the DSMB is 812 which is shown in Table. The organizational structure is shown in Figure.

**NUMBER OF STAFF, DSMB OF NUWA**

as of November 1990

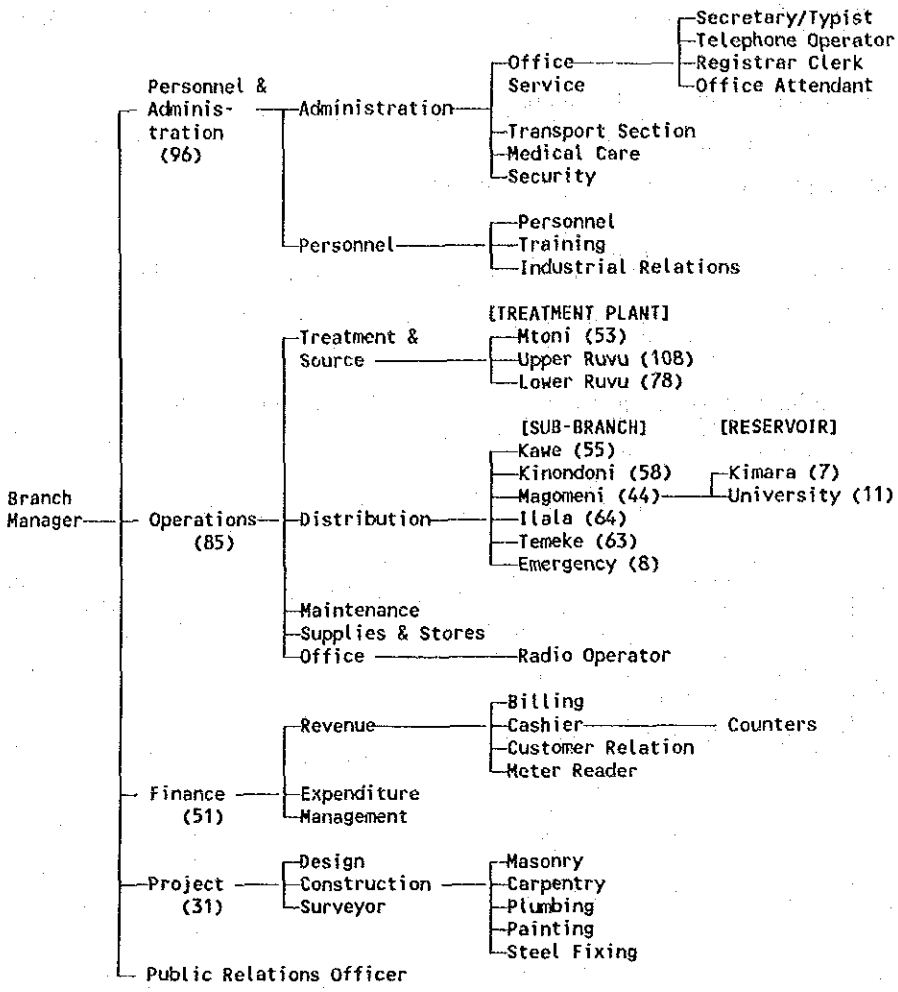
| Description | Operational | | | Admi. + Maintenance + Finance | | | Security | | Total |
|---|---|---|---|---|---|---|---|---|---|
| | Engineer | Technician | Artisan | Officer/ Accountant | Sub | Support | Officer | Guard | |
| Administration | 1 | 0 | 1 | 6 | 74 | - | 2 | 12 | 96 |
| Finance | - | 1 | - | 2 | 45 | - | - | 3 | 51 |
| Project | 3 | 20 | 8 | - | - | - | - | - | 31 |
| Operations | 6 | 33 | 21 | 6 | 19 | - | - | - | 85 |
| Upper Ruvu | 2 | 26 | 46 | - | - | 19 | - | 15 | 108 |
| Lower Ruvu | 3 | 26 | 31 | - | - | 7 | - | 11 | 78 |
| Mtoni | 1 | 22 | 19 | - | - | 3 | - | 8 | 53 |
| Ilala | 0 | 22 | 31 | - | - | 7 | - | 4 | 64 |
| Temeke | 0 | 27 | 27 | - | - | 2 | - | 7 | 63 |
| Magomeni | 0 | 23 | 27 | - | - | 6 | - | 14 | 70 |
| Kinondoni | 0 | 19 | 28 | - | - | 5 | - | 6 | 58 |
| Kawe | 0 | 24 | 25 | - | - | 1 | - | 5 | 55 |
| Sub total | 16 | 243 | 264 | 14 | 138 | 50 | 2 | 85 | 812 |

## 3.2 PRESENT MANAGEMENT CONDITIONS

### (1) TRAINING

NUWA has been sending its middle level technicians and craftsmen regularly to intensive courses in their respective fields for upgrading their respective skills. About 200 workers participate in such courses every year.

The DSMB conducts plant maintenance courses at the Lower Ruvu plant in collaboration with the Canadian International Development Agency (CIDA) which built the Lower Ruvu plant and has been providing operations and maintenance training, along with spare parts.




**ORGANIZATION OF DSMB, NUWA**

## (2) OPERATION

When NUWA started to function, Crown Agents prepared guidelines for day-to-day operations. In 1986, Crown Agents prepared manuals and recommendations for daily transactions in the directorate of finance, which includes the data processing section.

Even though facilities are very old, the treatment plants are being well-maintained by the plant engineers. The five sub-branch offices consist of four or five operating units, i.e. maintenance with leak survey, new connections, meter room, meter reader and pump attendants when booster pumps are installed.

### (3) COMPUTERIZATION

The master file of the payroll of NUWA is in the computer at the treasury. Only the billing system has been computerized so far. The hardware used is ICL ME 29, with a magnetic tape input and disc storage. Due to the increase in the number of consumers, the necessary field sizes of the variables ought to be expanded. NUWA received a new mini-computer and several personal computers in 1989. A mini-computer has been installed in the data processing room at Gerezani. The personal computers are used independently for tabulating financial documents.

## 3.3 FINANCIAL STATUS

According to the Urban Water Supply Act, NUWA is expected to break even financially, with revenue from sale of water covering all expenditures, including debt servicing charges and capital expenditure. NUWA is not required to make any profit from providing this service to the public.

### (1) WATER TARIFF

1) WATER TARIFF STRUCTURE

Despite incurring losses, no changes were made to the tariff structure until 1st July 1988. Due to this, NUWA had an overall deficit until the fiscal year 1987-88. The new water tariff is structured in such a way that NUWA should, at the very least, be able to break even. In this structure, consumer classification is employed in place of the flat rate charged earlier and different water rates are applied to different consumer groups. The new tariff ranges from Tanzanian Shillings (T.Shs.,U.S.$1=T.Shs.200 in March 1991) 57.25 per 1,000 gallons for domestic consumers to 248.40 T.Shs. for industrial customers.

Although monthly meter readings are to be used to calculate water charges, the DSMB of NUWA has only 669 metered connections in December 1989, which is only 1 % of the total number of connections. Therefore, for the most users, the water charge is based on the average water consumption, estimated by NUWA when the new tariff system was introduced.

2) WATER CONNECTIONS

The number of connections registered with NUWA is 59,020, as of December, 1989. However, numerous connections have not been registered with NUWA.

3) WATER CONSUMPTION BY CUSTOMER GROUP

Domestic consumption accounts for 59 % of the total consumption, although domestic billings account for only 31 % of the total billings. Industrial consumers, who consume 18 % of the water pay 41 % of the total billings. This is because the volumetric charge used for industrial consumers is 4.3 times as expensive as that for domestic consumers.

The amount of water supplied is about 136,500 $m^3$/day (30 mgd) , while the total water consumption, from water billing records amounts to 132,000 $m^3$/day (29 mgd). Although there are lots of illegal connections and kiosk connections that use water free of charge, the cost of this water supply is covered by legal customers, which has been the intention, since the amount of water supplied and the amount of water consumed, according to billings, are almost the same.

## (2) ACCOUNTING SYSTEM OF NUWA DAR ES SALAAM

### 1) BUDGETING

The director of finance has overall responsibility for producing the recurrent income and expenditure budget of NUWA. The capital budget is prepared by the director of programme planning & implementation and reviewed by the director of finance. In the context of DSMB, it is the responsibility of the branch accountant to estimate the income and expenditure of the branch; but it is that of the branch manager to ensure the budget of the branch is prepared according to the rules set by the Headquarters (HQ) and is delivered as per the schedule fixed by the HQ.

### 2) AUDIT

NUWA is required, by law, to submit its financial statements, after being audited by the Tanzanian Audit Corporation, together with the Director's report (annual report) to its parent ministry and to the National Assembly.

The audited report of NUWA for the fiscal year 1985-86 have been completed in March 1989 while the reports for 1986-87 & 1987-88, and 1988-89 have been completed in September 1989 and December 1989, respectively. Annual reports for the years after 1985-86 have not yet been prepared.

The auditors' reports indicate that the following are important points in the preparation of precise financial statements by NUWA:

- schedule of depreciation of fixed assets
- control of store and stocks, and
- billing and collection of water consumption revenue

## (3) FINANCIAL PERFORMANCE

NUWA has not achieved the financial requirement before the new tariff system was introduced on 1st July, 1988. The financial statements of NUWA are shown in Tables below.

## PROFIT - LOSS STATEMENT, NUWA

(Unit: T.Shs)

| | From 1/7/87 to 30/6/88 | 1/7/88 30/6/89 |
|---|---|---|
| INCOME | | |
| Operating Income | 198,047,067 | 930,610,655 |
| Non-operating Income | 1,136,679 | 2,491,782 |
| Total Income | 199,183,746 | 933,102,437 |
| EXPENSES | | |
| Operating Expenses | | |
| Salary & Wages | 42,802,564 | 43,023,183 |
| Chemical Expenses | 153,729,257 | 159,458,312 |
| Repair & Maintenance | 10,235,970 | 41,432,643 |
| Power Cost | 127,681,931 | 118,750,171 |
| Other Expenses | 20,478,202 | 29,574,387 |
| Total Operating Expenses | 354,927,924 | 392,238,696 |
| Administrative Expenses | | |
| Salary & Wages | 4,361,727 | 15,197,821 |
| Provision of Doubtful Debts | 0 | 237,075,593 |
| Other Expenses | 30,809,267 | 62,217,455 |
| Total Administrative Expenses | 35,170,994 | 314,490,869 |
| Audit Fees | 603,000 | 850,000 |
| Depreciation | 17,970,072 | 31,907,838 |
| Bank Charge | 937,294 | 2,388,265 |
| Total Expenses | 409,609,284 | 741,875,668 |
| Profit before Taxes | -210,425,538 | 191,226,769 |
| Taxes | 0 | 0 |
| Profit after Tax | -210,425,538 | 191,226,769 |
| Prior years' Adjustment | 0 | -48,265,540 |
| Accumulated Surplus | -498,647,006 | -355,685,777 |

## BALANCE SHEET, NUWA

| As at | 30/6/1988 | 30/6/1989 |
|---|---|---|
| Assets | | |
| Fixed Assets | | |
| Land & Buildings | 143,307,425 | 139,327,060 |
| Plant & Machinery | 4,638,686 | 3,785,718 |
| Water Supply Pipes | 183,176,161 | 171,745,932 |
| Motor Vehicles | 5,114,070 | 24,266,913 |
| Other Fixed Assets | 12,779,267 | 32,892,547 |
| SUB-TOTAL | 349,015,609 | 372,018,170 |
| Capital Work in Progress | 57,631,585 | 334,180,974 |
| Total Fixed Assets | 406,647,194 | 706,199,144 |
| Current Assets | | |
| Stock & Stores | 21,999,370 | 355,907,399 |
| Trade Debtors | 182,080,676 | 275,911,852 |
| Staff Debtors | 10,724,799 | 11,253,497 |
| Other Debtors | 9,713,148 | 56,419,805 |
| Unbanked Collections | 2,076,634 | 1,938,925 |
| Cash | 19,484,711 | 73,071,680 |
| Suspense Account | 0 | 1,938,925 |
| Total Current Assets | 246,079,338 | 774,503,158 |
| Total Assets | 652,726,532 | 1,480,702,302 |
| Equity & Liabilities | | |
| Equity | | |
| Capital Fund | 400,133,573 | 400,133,573 |
| Accumulated Surplus | 498,647,006 | -355,685,777 |
| Government Development Grant | 217,545,415 | 875,668,354 |
| Net Equity | 119,031,982 | 920,116,150 |
| Long-term Liabilities | 0 | 0 |
| Current Liabilities | | |
| Bank Account-overdrawn | 10,256,448 | 3,732,667 |
| Project Deposits | 7,206,840 | 10,114,071 |
| Salary Deductions Payable | 11,448,236 | 1,125,757 |
| Total Current Liabilities | 533,694,550 | 560,586,152 |
| Total Liabilities | 652,726,532 | 1,480,702,302 |

1) WATER PRODUCTION COSTS

Water production has been constant, while operating expenditures have increased 3.4 times between 1984-85 and 1988-89. This means that the unit production costs have increased at a rate of 36 % per annum during the last 5 years, which is greater than inflation in Tanzania, though it is lower than the rate of devaluation of T.Shs vis-a-vis the US dollar during the corresponding period.

Unit operating cost and unit administrative expenditure per 1,000 gallons of water produced is T.Shs 23.2 (T.Shs 5.1 per $m^3$) and T.Shs 4.4 (T.Shs 1.0 per $m^3$), respectively in 1988-89. Among operating expenses, chemical and power costs are the major cost items, followed by salaries and wages.

2) REVENUE AND REVENUE COLLECTION

Income from water consumption has increased at a rate of 40 % per annum between 1985-86 and 1987-88. Income in 1988-89 was 4.9 times that of the previous year.

There are a large number of bills that have been sent but not paid. The total revenue receivable in 1988-89 was T.Shs 922 million, although only T.Shs. 660 million were actually collected. This means that the default rate is about 30%.

3) SOURCE OF FUNDS

The source of funds are from operation surplus, capital and government development grants. NUWA has yet to take any long-term loans as of 1988-89. Accumulated surplus from operations is still showing a deficit of T.Shs. 356 million as of June end 1989 and after adjustment of depreciation and the accumulated fund generated from operation remains deficit of T.Shs. 199.5 million as at the end of June, 1989. Capital funds of the order of T.Shs. 400 million represent the net value of assets and liabilities taken over from DSM Water Supply Corporation Sole in October 1984. Through government development grants, T.Shs. 876 million have been accumulated, as of June end 1989.

**SOURCE OF FUNDS**

| | As at 30/6/83 | As at 30/6/84 | As at 30/6/85 | As at 30/6/86 | As at 30/6/87 | As at 30/6/88 | As at 30/6/89 | Accumulated |
|---|---|---|---|---|---|---|---|---|
| Fund Generated from Operations | 2.7 | 1.2 | -55.9 | -46.4 | -131.3 | -192.5 | 222.8 | -199.5 |
| Capital Fund | 0.0 | 0.0 | 400.1 | 0.0 | 0.0 | 0.0 | 0.4 | 400.5 |
| Government Development Grant | 0.0 | 5.9 | 1.0 | 14.2 | 148.4 | 48.1 | 658.1 | 875.7 |
| Total | 2.7 | 7.1 | 345.2 | -32.2 | 17.1 | -144.4 | 881.3 | 1076.7 |

4) UNACCOUNTED FOR WATER

It is estimated that water consumption through registered connections accounts for 30% of net water

supply. Consequently 70% of the net water supply is unaccounted; 35 % as leakage, 29 % as illegal connections and 6 % as no connections (standpipe/kiosk).

### (4) BUDGET FOR 1989-90 AND 1990-91 FISCAL YEARS

The budgetary deficit is estimated to be T.Shs 905.0 million in the fiscal year 1990-91. Revenue is estimated to be T.Shs 1,016.5 million and the expenditure of the DSM Branch office is estimated to increase 96 % over the previous fiscal year.

NUWA has forwarded the proposal of 68 % tariff increase to the Ministry of Water, Energy and Minerals for consideration, which is designed to be operated at break even.

## 4 WATER SUPPLY SYSTEM

### 4.1 LOWER RUVU SYSTEM

### (1) OUTLINE

In 1976, the Lower Ruvu treatment plant was commissioned, together with transmission mains and new reservoirs in the City. It has a capacity of 182,000 $m^3$/day (40 mgd) and accounts for two-thirds of the total capacity in DSM water supply system. However, the filtration unit has been out of service.

The treatment plant comprises of the unit operations of flocculation and clarification, utilizing alum as the coagulant and, at times, activated silica as coagulant aid. Clarification is followed by rapid sand filtration. Disinfection is by addition of either liquid chlorine from one-ton cylinders or calcium hypochlorite solution. As the water is aggressive in nature, sodium carbonate is used for neutralization.

Equipment used for operations & maintenance and spare parts for repairs, most of which are imported, have been in short supply. Hence, preventive inspection of concrete tanks, machinery etc. have not been regularly performed. Further, repairs that have become necessary have been delayed for long periods. Efforts, however, were concentrated on equipments like pumps, which were absolutely essential, to the detriment of other equipment, which were left unattended or even abandoned. Such neglect often led to equipment trouble. As a result, the plant operated under considerable difficult operating conditions. Machinery trouble and equipment failure immediately leads to water supply suspension. The above comments are also applicable to the Mtoni plant.

### (2) PLANT OPERATION

The raw water contains large quantities of suspended solids - silt and sand. Even in the dry season, turbidity exceeds 100 JTU with an annual average of 200 - 500 JTU. The raw water also contains very fine non-settlable and colloidal particles. Dosing rates of alum are from 5 to 30 mg/l.

### (3) FACILITIES

The two radial gates, one each on the intake channel discharge and on the intake by-pass channel, appear to be in disuse. The radial gates or its substitutes have to be rehabilitated in order that sufficient differential head across the gates be made available to provide adequate flushing velocity, so that silt deposits in the distribution pipe will be decreased considerably.

Presently, one intake main is in use to convey raw water from the intake to the raw water lift pumping station. Molluscs adhere to the inner surface of the pipes, with the result that flow is blocked, especially when there was low flow in the river. Consequently, NUWA has been removing molluscs, as a preventive measure, once every few months. However, this usually takes the whole daytime, during which time the plant has to be shut down.

Three pumps have been installed, each delivering 50 percent of the design capacity. Since there are no float gauges in the raw water pumping station, there is danger of excessive draw-down resulting in drastic damage to the raw water pumps. To rectify this situation, it is suggested that a new sensor be placed to detect the low water level.

The leakage taking place in the sludge pipe under or near the clarifier needs to be repaired. This repair requires semi-tunnelling or pushing under the existing clarifier.

The filter plant has been totally inoperative. There is no sand in any of the filters, and some of the strainers have become dislodged, broken, or in some cases, no longer in the filter unit. Clay and colloid have accumulated on the inside of the filter unit.

Normally, in most water treatment plants, of all the equipment and machinery, chemical dosing equipment are subjected to maximum corrosion and are liable to go out of order often, and have to be replaced within 4 to 5 years of their installation. In this plant, however, this is not the case. They have been maintained well with the exception of some small equipment.

A small but important 3/4" steel pipe from the 1 ton chlorine gas container to the chlorinator is corroded and had better be replaced.

## 4.2 MTONI SYSTEM

### (1) OUTLINE

The Mtoni plant, which is very small and very old, is located in the south of the city, approximately 7 km from the city centre. Raw water is delivered to a horizontal zig-zag flow flocculation basin. The mixture is then delivered to six hopper-bottom, vertical flow clarifiers which are designed to utilize a

single blanket for flocculation/ clarification.

There are three rapid sand filters, each with an area of 28 $m^2$. At the normal filtration rate of 1.5 gpm per square foot (106 m/day), the total filter capacity is 1.9 mgd (8,645 $m^3$/day).

The water is then treated with soda ash to adjust the pH and chlorinated before being discharged to a 2.0 million gallon (9,100 $m^3$) storage reservoir. The storage water level is 131 feet (39.9 m) and the water must be pumped to the distribution system. The pumping station also functions as a booster pumping station for areas further south of Mbagala, and to supplement supply to the southern areas with water from the Lower zone.

There exist two apparent problems in the present operation. One is the worn-out condition of the system due to aging of plant facilities and the other is a shortage in intaken water, particularly in the dry season caused by low runoff in the river.

**(2) WATER SOURCES**

1) CURRENT WATER SOURCES

Water from the Kizinga river is the only source currently used for the Mtoni plant. No record of the amount of water intaken is available. According to NUWA, however, the daily intake volume is 1.7 mgd (7,700 $m^3$/day) during the wet season and this decreases to 0.3 mgd (1,400 $m^3$/day) during the dry season.

2) POSSIBLE INTAKE OF EXISTING WATER SOURCES

- Kizinga Dam - Planned Supply : 4.75 mgd (21,600 $m^3$/day)
- Mzinga Dam - Planned Supply : 17 mgd (77,300 $m^3$/day)

Either dam would be able to supply more than the water required by the existing Mtoni plant. However, dam construction is not recommended at the present time prior to consideration of alternatives such as Ruvu river or Wami river development. The cost of dam construction is very exorbitant, if it is only to act as a supplementary source for the existing Mtoni plant. The construction should be considered within the overall framework of other water supply system expansion schemes.

**(3) PLANT OPERATION**

Daily water quality analysis has not been conducted in the plant for more than 6 years. To monitor water quality, samples were collected and sent to the Soil and Water Laboratory of the Ministry of Water, Energy and Minerals, once or twice a month. Raw water alkalinity is lower than in the raw water at Lower Ruvu plant. This would suggest the necessity for pH adjustment by alkaline dosing in the coagulation process.

The dosing rates of alum vary from 35 to 107 mg/l. The higher rate may adversely affect coagulation by decreasing the pH. Chlorine injection rates vary widely. This implies improper control of the dosing rate.

**(4) FACILITIES**

At present, the Mtoni water supply system is in disarray due to its advanced age.

All the walls need be painted to protect them from corrosion. Steel patching work is needed on the walls of effluent channels to stop leakage. Baffle walls need to be repaired to prevent short-circuit flow and foundations need be reinforced.

Presently, due to corrosion, half the troughs have fallen out, making it very difficult to perform its function in the clarifiers. Out of six sludge valves, three are not water-tight. All six valves are to be replaced. It is recommended that new effluent troughs be added. Even timber troughs or half-cut PVC pipe can serve this purpose.

When backwashing was performed, water distribution was not uniform. Even after regrading and re-sieving the filter sand, this was not the case. Strainers were found to be defective and need to be replaced. Further, two of the three washout valves are not watertight.

The inside surface of the alum solution tank is very corroded and has to be repaired. Mixers, using timber rods as replacement, provide for make-shift operation. Hence, new mixers should be installed to replace old mixers. Stainless steel should replace steel in the rotary propeller. Currently, only one of the two dosing pumps is operational, and even this is highly worn out, due to age. New pumps should replace the old ones.

The existing gravitational piping and valves of the soda ash dosing equipment are highly corroded. New pipes and valves should be of highly corrosion resistant and durable materials.

Presently, chlorine gas as well as calcium hypochlorite are used for disinfection. The gas dosing equipment is working well even though it does not contain platform scales. Calcium hypochlorite is also fed without measuring devices. Therefore, equipment for control of the feed calcium hypochlorite dose is necessary.

## 4.3 DISTRIBUTION SYSTEM

**(1) OUTLINE**

The distribution system is divided into two zones, one called the Upper Zone, serving the high eleva-

tion areas from the Kimara reservoir, and the other called the Lower Zone, serving the low elevation areas from the University reservoir and the Mtoni system. Both the Upper and Lower zones are gravity-fed systems.

In order to make a preliminary pipe inventory, maps drawn to either a 1:2,500 or 1:5,000 scale, had been distributed to all five sub-branches of NUWA. On these maps, it has been requested that proper information regarding alignment, size, material and installation year of pipes be filled in. With this information and drawings available with NUWA, an inventory has been processed. According to this, the total length of distribution pipes is 821 km, consisting of 237 km of primary distribution pipes and 584 km of secondary and tertiary pipes.

Main (primary) pipes are pre-stressed concrete, steel and cast iron/ductile iron pipes. Pre-stressed pipes were laid in the late 70s, at the time of commissioning of the Lower Ruvu system, while the other pipes were mostly laid before the 70s, when the Upper Ruvu system was commissioned. External corrosion of cast iron pipes is negligible with the coal tar (or bitumen) coatings being relatively damage free.

As to secondary pipes, the city center, the southern area (Mtoni, Chang'ombe, Keko and Kurasini areas) and the northern area (Oyster bay and Kinondoni areas) were covered by the water supply system in the 1950's. The remaining areas in Kinondoni between the city center and the Oyster bay area were covered in the early 60s. In the late 60s, under the development of the Lower Ruvu system, the western areas such as Magomeni, Manzese and Sinza were covered by the water supply system. Since 1970's, very few pipes have been laid.

The length of PVC pipes is greater than that of cast iron pipes in newly-developed areas, i.e., Kawe sub-branch, while the reverse is true in areas of the remaining sub-branches that were developed earlier.

As for service pipes, galvanized steel pipes, mostly 3/4 or 1 inch in diameter, were initially used. Recently, PVC has become more popular. The galvanized steel service pipes, especially those laid in moist, sandy clay and marshy areas are subject to corrosion in about 7 to 10 years time.

**(2) LOW PRESSURE AREAS**

There are areas of the City receiving supplies only at night when demand from other areas drop and system pressures rise.

In general, water pressure is acceptable in areas surrounded by the New Bagamoyo road in the north, the Indian ocean in the east and Pugu road in the south. The hypothetical western boundary lies be-

tween Morocco/New Kigogo roads and Mandela road. These areas are the urbanized areas where secondary distribution system has been fairly well developed. More importantly, large-sized distribution mains enclose the areas. These areas are only about 30% of the total supply area.

On the other hand, water pressures are low in the peripheral areas, outside the above-mentioned hypothetical boundaries. These areas are recently-developed areas, and hence the primary distribution mains have not been sufficiently developed or are under-sized in places where they exist.

Although available pressures of more than 1 bar within the rest of the network indicate that most of the distribution system should be adequately supplied, this is not reflected in the current level of service. The main problem is the state of the secondary pipe distribution system. Since most of the secondary distribution system consist of old cast iron pipes, there is significant hydraulic loss primarily due to silt and encrustation of the pipes.

**(3) LEAKAGE AND WASTAGE IN TRANSMISSION LINE**

Measurements have indicated that large quantities of water are consumed or lost upstream of the service reservoirs, where high pressure exists - ranging up to 110 meters and averaging 60 meters. Countermeasures for reducing leakage and wastage are underway in the Upper Ruvu system.

**(4) WATER LOSSES IN THE SYSTEM**

Water losses also exist in the distribution system, house service pipes, valve seatings and public standposts, and have been estimated to be 35 %. The current system of leakage control is passive control, where leaks are repaired when reported either by the public or NUWA personnel engaged in other tasks.

**(5) SILT AND ENCRUSTATION**

Field observations of pipe samples removed from various sites have revealed that the cross-sectional areas of the pipes have been reduced to less than 50%. Blockages consisted mostly of loose deposits of silt, typically, though tuberculation was also observed.

Pipe blockage and reduction in effective internal area was large in smaller diameter pipes, i.e. diameter less than 150 mm. On the other hand, there was no blockage or area reduction in large diameter pipes, i.e. diameter greater than 200 mm.

On the contrary, no external corrosion was observed and the pipe was largely intact. This means that the existing pipes can be used further and pipe renewal methods can be employed. Pipe renewal is much more feasible than pipe replacement, considering the relatively high cost of pipe replacement, and relatively low cost for labour required in pipe renewal.

### (6) DISCONNECTING PIPES IN KEY LOCATIONS

An earlier report on the distribution system has already highlighted a number of suspected operational difficulties. This involved trial pitting to determine pipework details. Accordingly, pipe connections were inspected in key locations through trial pitting. As a result, many disconnected pipes and closed valves were found.

### (7) LACK OF DISTRIBUTION PIPE NETWORK

Few distribution pipes have been laid since the early 70s. As a result, existing pipeline areas as well as new areas need installation of new pipelines. Inadequate pipe diameter is a major cause of low pressure in areas identified in the preceding section.

### (8) LONG SERVICE PIPE

Due to the inability of NUWA to install sufficient secondary distribution mains, an extensive network of long, small diameter service mains have developed. These mains encounter physical damage as a result of being installed at a very shallow depth; it is common for the service pipe to rise vertically from the mains and then run at a shallow depth into the consumer premises. Pipe are mostly of galvanized mild steel or polyethylene. Internal house fittings are generally old and of poor quality. Incomplete shut-off and leakage results.

### (9) MIDDLE ZONE

After the various measures proposed are implemented, water supply to low pressure areas will be alleviated to a considerable degree. However, excessive pressure will be experienced in some areas and will produce an adverse effect on the distribution system under the current zoning plan. This will result in loss of surplus water for distribution to, firstly, some high elevation areas and secondly to hydraulically unfavourable areas. Therefore, effective water use is to be considered - pressure control or pressure reduction in high pressure areas.

When setting up the middle zone, a part of western Temeke should be separated from the current lower zone and incorporated into the middle zone. The area has chronically suffered from low water pressure due to relatively small head differential from the University reservoir.

## 5 REHABILITATION PROJECT

### 5.1 PRINCIPLES OF REHABILITATION

### (1) IMPROVEMENT OF FINANCIAL CAPABILITY

A chronic water supply shortage problem is not merely a technical matter. It has long been caused by,

to a great degree, inadequate financial resources.

Although continued reliance on external sources for capital investment is inevitable for some time to come, internal sources should also be vigorously explored. In this connection, measures already initiated aimed at increasing revenue and listed below should be emphasized.

1) follow-up efforts to decrease illegal connections, thereby increasing revenue for NUWA;
2) improve revenue collection to increase the amount of cash being collected.

These will enhance NUWA's financial capability, autonomy and sustainability. This will also lead to gradually eliminating the annual operating deficit and reduce the need for government assistance.

Water has been regarded as one of the basic human needs. On the other hand, the water supply system is also an infrastructural item, like electricity and telephone systems. Due to water being vital for sustenance of human life, the tariff system should be low, with unit costs and progressively increasing unit charge system for large domestic consumers.

**(2) PROPER OPERATION AND MAINTENANCE**

Improvement in operations is essential for managing water supply systems;

1) maintain and operate pumps and treatment plants with a minimum of breakdown to avoid disruptions in supply;
2) identify the data base of NUWA and have accurate records of production, water supplied, leakage, consumers and their accounts; and
3) maintain and operate vehicles and plants with minimum downtime to enable the above activities to be undertaken in the shortest possible time.

The replacement of entire equipment is not cost-effective, compared to replacement of parts. Therefore, repairs must be timely, without delay, as another adage aptly states - a stitch in time saves nine.

**(3) EQUAL DISTRIBUTION**

Technically, the eventual goal is to supply adequate, clean and safe water efficiently at a reasonably low cost. However, due either to inadequate pressure in the existing distribution network or due to the lack of distribution network especially in peripheral service area, about 70% people in service area are suffering from a shortage of water.

As a first step towards reaching the final goal, the technical goal of the 5 year rehabilitation project is set at supplying safe water equitably for whole service area.

## 5.2 TARGET

The target year for the rehabilitation plan is set at 1995. Supply cannot suffice daily maximum demand in 1995 . Hence, the target level to which we can reach is to meet the daily average demand. Whether or not the available quantity can meet the daily average demand in the city, depends on the level of the leakage control attained, which is a part of the proposed rehabilitation work. It is possible if the leakage (including the wastage) level is reduced to less than 25% from the current 35% level.

## 5.3 FRAMEWORK OF REHABILITATION PROJECT

### (1) SUPPLY TO THE CITY

Out of the combined total output, 205,900 $m^3$/day will be available for DSM in 1995. This amount is greater than the amount available now, which is 193,400 $m^3$/day.

**WATER SUPPLY IN 1995**

Unit : $m^3$/day (mgd)

| | Lower Ruvu | Upper Ruvu | Mtoni | Total | Percentage |
|---|---|---|---|---|---|
| Output at the Plant | 181,800(40) | 82,000(18) | 6,800(1.5) | 270,600(59) | 100 % |
| Consumption or Leakage along Transmission Line | 32,700( 7) | 32,000( 7) | ..... | 64,700(14) | 24 % |
| At the Reservoir (for Dar es Salaam) | 149,100(33) | 50,000(11) | 6,800(1.5) | 205,900(45) | 76 % |

### (2) 1995 WATER DEMAND

The total population of DSM in 1995 is estimated as 1,731,381, at a 3.5 % rate of increase per annum. The per capita water consumption is estimated to be at 1990 levels. The total consumption in DSM will be 164,338 $m^3$/day (36 mgd) in 1995 on a daily average base, out of which domestic consumption will be 145,034 $m^3$/day.

## 5.4 PROJECT SELECTION

### (1) PROJECT IDENTIFICATION

The various projects are identified from the following considerations;

Despite the worn-out condition of the facilities, it is better to avoid full-scale rehabilitation of the Mtoni system until its future is decided, based specially on a study of water resources. Instead, it is better to attempt piecemeal rehabilitation for this system, aimed at prolonging the existing facilities, as long as possible, at least possible cost.

The Lower Ruvu system has been working properly due to daily operation and maintenance by the staff and timely repair, aided by CIDA. Since these favourable circumstances are expected to continue, this system will continue to function at its full capacity.

The Upper Ruvu system rehabilitation works has been completed by the end of 1990, and it is outside the scope of this study, according to the scope of work.

The objectives of the rehabilitation project in the distribution system are to identify and remove bottlenecks in inadequately supplied areas.

The identified solutions are grouped as follows:
a. Leakage control measures in the transmission system
b. Leakage control measures in the distribution system
c. Existing pipe connections
d. Main pipe laying (primary)
e. Main pipe laying (secondary)
f. Pipe cleaning
g. Middle zone creation
h. Treatment plant (water volume)
i. Treatment plant (prevention and water quality)
j. Metering

**(2) PROJECT SELECTION**

Since the target of the project is to supply water adequately, all measures except item i above can be selected. This selection is further examined from a cost benefit analysis.

Cases considered in doing a cost-benefit analysis are shown in Table, reflecting the implementation order, which is governed by the quantity of water saved. For example, leakage control measures are assumed to be implemented first because other measures such as pipe laying will not be effective, since no surplus water will be available unless leakage control measures are implemented.

The cost-benefit analysis shows that B/C ratio of case 5 exceeds 1.0 while that of case 6 does not reach 1.0. Therefore, case 5, viz. all works in the distribution system and work relating to the water volume in the treatment system , can be selected. The selected projects are listed in Table and are also shown in Figures. Metering (item j above) is selected without the cost benefit analysis since it shows financially viability.

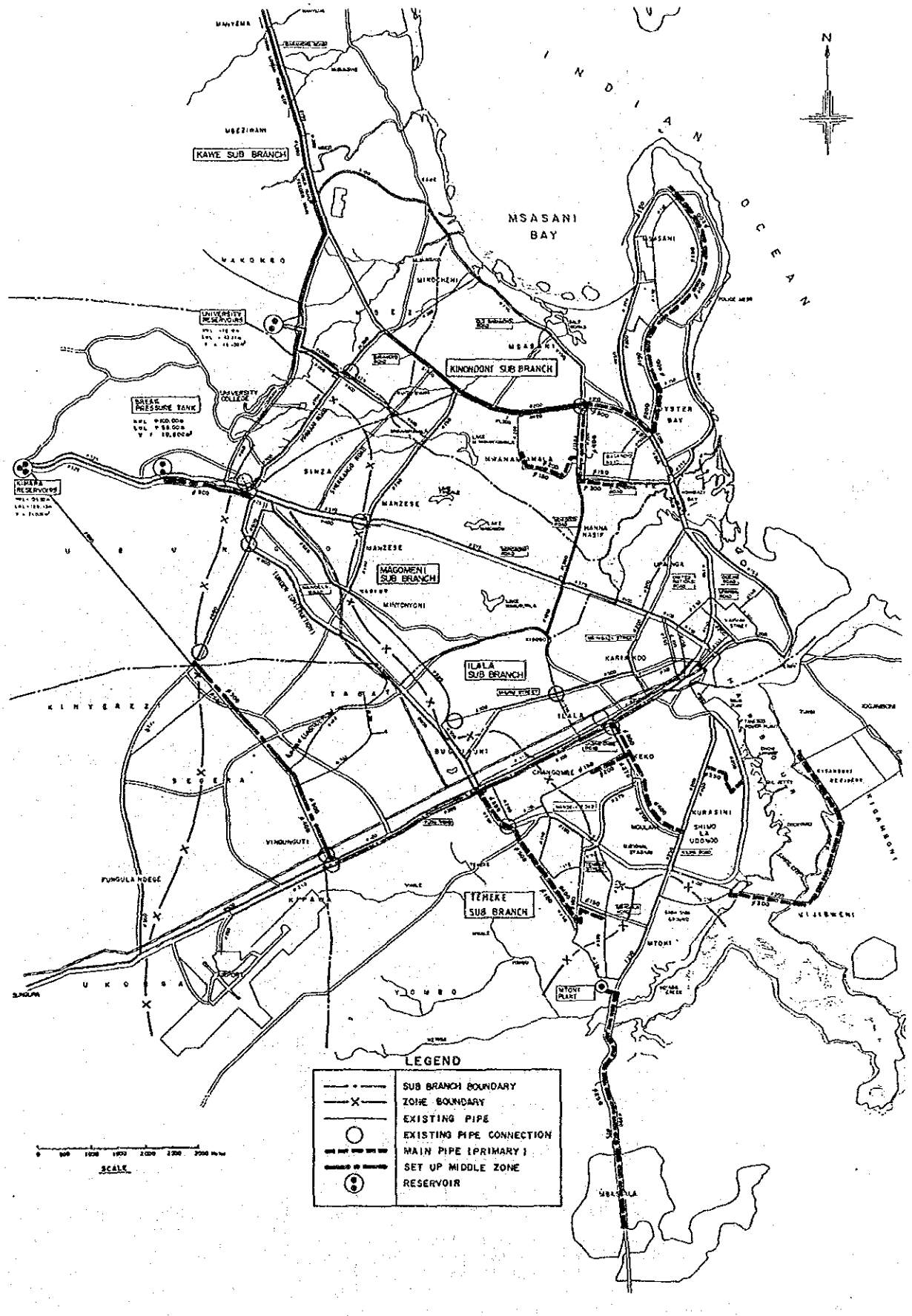
## PROJECT CASE FOR ECONOMIC EVALUATION

| | PROGRAMME \ CASE | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 | Case 6 |
|---|---|---|---|---|---|---|---|
| a | Leakage control measures (transmission) | O | O | O | O | O | O |
| b | Leakage control measures (distribution) | O | O | O | O | O | O |
| c | Existing pipe connection | X | O | O | O | O | O |
| d | Main pipe laying (primary) | X | X | O | O | O | O |
| e | Main pipe laying (secondary) | X | X | O | O | O | O |
| f | Pipe cleaning | X | X | O | O | O | O |
| g | Middle zone | X | X | X | O | O | O |
| h | Treatment Plant (water volume) | X | X | X | X | O | O |
| i | Treatment Plant (prevention and quality) | X | X | X | X | X | O |

LEGEND : O = project marked O is included in case,
X = project marked X is not included in each case.

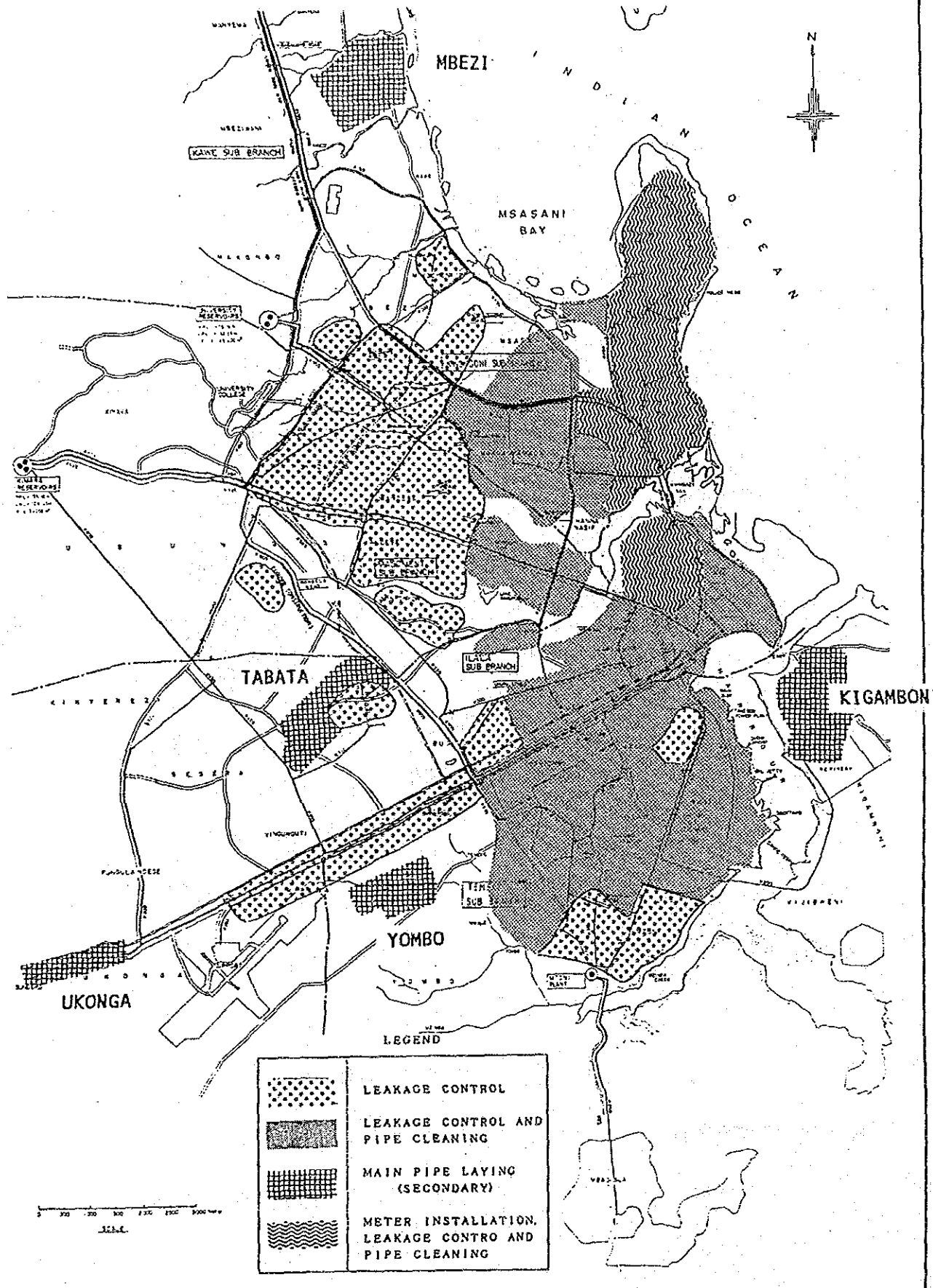
## SELECTED PROJECT

| Works Description | Unit | Quantity |
|---|---|---|
| **A.IN-HOUSE ACTIVITY (continuous work items)** | | |
| j) Meter installation | each | 15,000 |
| b) Leakage control measure in the distribution system (including mapping system) | lump sum<br>lump sum | 1<br>1 |
| f) Pipe cleansing | | |
| 1 Air scouring | meter | 417,000 |
| 2 Scraping & lining | meter | 213,000 |
| **B.CONTRACTUAL WORK (non-continuous work items)** | | |
| a) Leakage control measure (transmission system) | | |
| 1 Replace pressure reducing valve | each | 16 |
| 2 Replace meter in off-takes | each | 16 |
| b) Leakage control measure (distribution system) | | |
| replace service pipe with distribution pipe | meter | 90,000 |
| c) Existing pipe connection | each | 14 |
| d) Main pipe laying (primary) | | |
| 1 Supply and lay pipe (kinondoni, 400 - 200 mm ) | meter | 4,600 |
| 2 Supply and lay pipe (msasani, 500 - 200 mm) | meter | 6,700 |
| 3 Supply and lay pipe (temeke, 500 - 400 mm) | meter | 4,300 |
| 4 Supply and lay pipe (kurasini, 500 -200 mm) | meter | 4,800 |
| 5 Supply and lay pipe (kigamboni, 300 mm) | meter | 5,100 |
| 6 Supply and lay pipe (mbagala, 250 mm) | meter | 5,100 |
| e) Main pipe laying (secondary) | | |
| 1 Supply and lay pipe at mbezi | meter | 14,300 |
| 2 Supply and lay pipe at tabata | meter | 9,300 |
| 3 Supply and lay pipe at ukonga | meter | 4,400 |
| 4 Supply and lay pipe at yombo | meter | 8,300 |
| 5 Supply and lay pipe at kigamboni | meter | 10,500 |
| g) Middle zone | | |
| 1 Break pressure tank | $m^3$ | 10,600 |
| 2 Supply and lay pipe at ubungo | meter | 2,800 |
| 3 Supply and lay pipe at vinguguti | meter | 5,000 |
| h) Treatment plant | | |
| 1 Lower ruvu treatment plant | | |
| S & I water level sensor,sludge pipe,chlorinator pipe | lump sum | 1 |
| 2 Mtoni treatment plant | | |
| Repair coagulation basin, alum dosing equipment, | lump sum | 1 |
| soda ash dosing equipment,disinfection equipment | lump sum | |



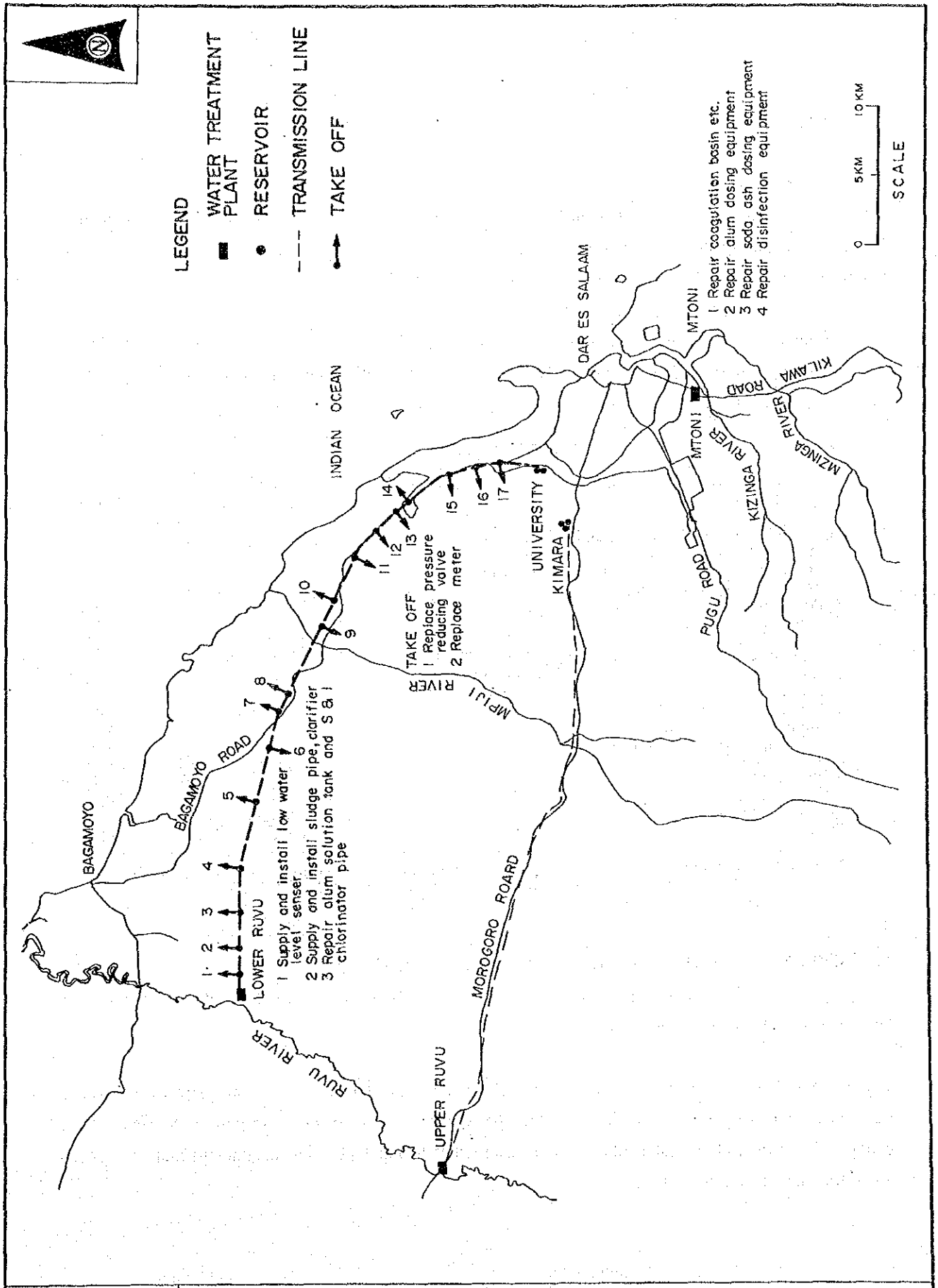

PROPOSED REHABILITATION PROJECT
- DISTRIBUTION SYSTEM (PRIMARY) -

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY




PROPOSED REHABILITATION PROJECT
- DISTRIBUTION SYSTEM (SECONDARY) -

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY




PROPOSED REHABILITATION PROJECT
- TREATMENT PLANT AND TRANSMISSION LINE -

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

## 5.5 PROJECT COST

### (1) COST ESTIMATE

Costs required for the proposed rehabilitation projects are estimated, based on prices prevailing in November 1990. Basic costs are provided here, and these do not include physical contingencies and administrative costs, which are given in the "disbursement schedule".

Table summarizes the basic cost estimated for each rehabilitation item, broken down into foreign and local currency portions. The total estimated cost is T.Shs.7,680 million, broken down into a foreign currency portion of T.Shs.5,535 million and a local currency portion of T.Shs.2,146 million.

**TOTAL PROJECT COST**

(Unit : T.Shs.million)

| Description | F.C. | L.C. | TOTAL |
|---|---|---|---|
| **IN-HOUSE WORKS (CONTINUOUS WORKS)** | | | |
| 1. Meter installation | 524 | 15 | 538 |
| 2. Leakage control measure (Distribution system) including mapping system | 1,095 | 171 | 1,266 |
| 3. Pipe cleaning | 619 | 80 | 699 |
| 4. Arrears, illegal connection | 0 | 123 | 123 |
| SUB-TOTAL | 2,237 | 388 | 2,625 |
| **CONTRACTUAL WORKS (NON-CONTINUOUS WORKS)** | | | |
| 1. Leakage control measure (Transmission System) | 31 | 12 | 43 |
| 2. Leakage control measure (Distribution system) | 180 | 432 | 612 |
| 3. Existing pipe connection | 238 | 58 | 296 |
| 4. Main pipe laying (primary) | 1,492 | 338 | 1,830 |
| 5. Main pipe laying (secondary) | 121 | 245 | 366 |
| 6. Middle zone | 1,181 | 667 | 1,848 |
| 7. Treatment plant | 54 | 5 | 59 |
| SUB-TOTAL | 3,297 | 1,757 | 5,054 |
| TOTAL | 5,535 | 2,146 | 7,680 |

Note: F.C.= Foreign currency, L.C.= Local Currency portion (at November, 1990 price level)
Exchange rate US$ 1 = T.Shillings 200 = Japanese Yen 140
Total values may not match due to rounding-off.

### (2) IMPLEMENTATION AND DISBURSEMENT SCHEDULE

The proposed rehabilitation project must be carried out systematically in order to obtain the maximum benefit from the limited resources available.

The estimated costs and the implementation schedule were combined to produce a project cost disbursement schedule, as given in Table. Fifteen percent was added to the basic cost as physical contingency and administrative costs. Inflation was assumed as 5 % per year for foreign currency portion and 30 % for local currency portion.

## DISBURSEMENT SCHEDULE

(Unit: Million Tanzanian Shilings)

| Description | TOTAL | 1991 | 1992 | 1993 | 1994 | 1995 |
|---|---|---|---|---|---|---|
| A.IN-HOUSE WORKS (CONTINUOUS WORKS) | | | | | | |
| 1.METERING SYSTEM | 538 | 277 | 253 | 3 | 3 | 3 |
| 2.LEAKAGE CONTROL MEASURE(DISTRIBUTION SYSTEM) | 1,254 | 397 | 275 | 252 | 184 | 145 |
| 2' MAPPING SYSTEM | 12 | 6 | 2 | 2 | 2 | 2 |
| SUB TOTAL | 1,266 | 403 | 277 | 254 | 186 | 147 |
| 3.PIPE CLEANING | 699 | 424 | 69 | 69 | 69 | 69 |
| 4.ARREARS AND ILLEGAL CONNECTION | 123 | 25 | 25 | 25 | 25 | 25 |
| TOTAL (IN-HOUSE ACTIVITY) | 2,625 | 1,129 | 622 | 350 | 281 | 243 |
| B.CONTRACTUAL WORKS (NON-CONTINUOUS WORKS) | | | | | | |
| 1.LEAKAGE CONTROL MEASURE (TRANSMISSION LINE) | 43 | 43 | | | | |
| 2.LEAKAGE CONTROL MEASURE (DISTRIBUTION SYSTEM) | | | | | | |
| Replace service pipe with distribution pipe | 612 | | | | | 612 |
| 3.EXISTING PIPE CONNECTION | 296 | 296 | | | | |
| 4.MAIN PIPE LAYING (PRIMARY) | 1,830 | | 655 | 1,175 | | |
| 5.MAIN PIPE LAYING (SECONDARY) | 366 | | | | 366 | |
| 6.MIDDLE ZONE | 1,848 | | | | | 1,848 |
| 7.TREATMENT PLANT | 59 | 58 | 1 | .. | .. | |
| TOTAL (CONTRACTUAL WORK) | 5,054 | 397 | 656 | 1,175 | 366 | 2,460 |
| TOTAL | 7,680 | 1,526 | 1,280 | 1,526 | 648 | 2,704 |
| PHYSICAL CONTINGENCY | 1,151 | 229 | 191 | 229 | 97 | 405 |
| PRICE CONTINGENCY | 5,606 | 132 | 288 | 631 | 775 | 3,780 |
| GRAND TOTAL | 14,436 | 1,887 | 1,757 | 2,384 | 1,519 | 6,888 |

(at November,1990 price, 1 US$ = T.Shs.200 = Japanese Yen 140)

## 5.6 PROJECT EVALUATION

### (1) FINANCIAL ANALYSIS

Table shows a summary of the calculated results of financial internal rate of return (FIRR) and the net present value (NPV) at discount rates of 3% and 10%.

### SUMMARY OF FINANCIAL ANALYSIS OF THE PROJECT

| | NPV at discount rate (T.Shs.million) | | B/C at discount rate | | FIRR |
|---|---|---|---|---|---|
| | 3% | 10% | 3% | 10% | |
| Reduction in illegal connection & bad debts | | | | | |
| 0 % | -5,259 | -5,500 | 0.57 | 0.39 | |
| 10 % | -3,644 | -4,690 | 0.70 | 0.48 | |
| 20 % | -1,982 | -3,856 | 0.84 | 0.57 | 0.3% |
| 30 % | -262 | -2,995 | 0.98 | 0.67 | 2.6% |
| 40 % | 1,504 | -2,111 | 1.12 | 0.77 | 4.9% |
| 50 % (Basic Case) | 3,330 | -1,198 | 1.27 | 0.87 | 7.2% |
| 60 % | 5,199 | -265 | 1.43 | 0.97 | 9.4% |
| 70 % | 7,117 | 692 | 1.58 | 1.08 | 11.6% |
| 80 % | 9,079 | 1,671 | 1.75 | 1.18 | 13.8% |
| 90 % | 11,099 | 2,678 | 1.91 | 1.30 | 16.0% |
| 100 % | 13,180 | 3,714 | 2.08 | 1.41 | 18.2% |

As shown in Table, the NPV of costs exceeds that of benefits, discounted at 3%, in four cases, where reduction of illegal connection and bad debts are estimated to be 0%, 10%, 20% and 30%. If the reduction cannot be expected to be 40% or more, the Project cannot be acceptable from a financial point of view. When it is reduced to 40%, the FIRR to the project is estimated at 4.9% which indicates the minimum rate to justify the Project.

The FIRR of the Basic Case shows 7%. However, it is expected that improvement of greater than 50% is possible. Accordingly it is desirable to improve the reduction to 70% , when the benefit cost ratio exceeds 1.0 discounted at 10%.

The proposed project can be acceptable from a financial point of view by raising the reduction. The required reduction should be at least 40% or more.

**(2) FINANCIAL PLAN**

The total capital costs during 1991-1995, including inflation, estimated at 5% for the foreign currency portion and 30% for local currency portion, amount to T.Shs.12,206 million, out of which T.Shs.7,155 is the foreign currency portion and T.Shs.5,051 is the local currency portion.

The financing for the Project has yet been unidentified, however tentative financing plans have been formulated. Other than revenue generated, project costs will usually be financed by:

- Grants from government
- Soft loans (at subsidized rates)
- Hard loans (at commercial rates)

Using the most optimistic projection (100% reduction) to estimate the benefits of the reduction in illegal connections and bad debts, the FIRR of the Project has been estimated at 18.2 %. It is lower than the commercial interest rate of long-term loans in Tanzania, which was 20-30% in 1990. Therefore subsidies in the form of soft loans or grants are required to implement the Project.

If the reduction in illegal connection and bad debts is only 40%, it is required that a greater part of the capital costs of the Project be subsidized grants.

In order to implement the Project, financed by soft loans, illegal connections and bad debts should be reduced by 30% in 1995. In any case, it is clear that massive administrative input is needed from NUWA for the projects.

**(3) ECONOMIC IMPACT**

The principal economic benefit of a water supply project is reduction of water borne diseases, due to

improved water quality and quantity. The impact of drinking water quantity on health is high during water shortages, when water borne diseases can be transmitted from person to person in different ways.

The prime objective of the proposed project is to provide an adequate supply of water to the customers in DSM. Water savings of 33,000 $m^3$ per day is realized from leakage control and 11,900 $m^3$ from wastage control. Water saved is re-distributed to the users.

The consumers' willingness to pay resulting from increased water consumption has been estimated, as reflected by the charges for water consumption. The rehabilitation projects have been selected at the level in which the benefit cost ratio exceeds 1.0, discounted at 3%. Increased consumers' willingness to pay and the costs of the proposed project are estimated at 10,589 and 10,347 T.Shs.million, respectively, discounted at 3%.

The time saved from carrying water is also an economic benefit of water supply project. The time saving is highly valuable since so much time and energy of women and children are spent in order to provide water. The time saving would be also realized from the Project to some extent.

Metering is also efficient from an economic point of view. Water losses is expected to reduce by 10 % by meter installation and saved water in 15,000 households will amount to 1,996 thousand $m^3$ per year.

About 70 % the DSM population live in areas with inadequately supply in 1990. This will surely increase in 1995, taking into account the increasing demand and the constant supply amount. 80 % or about 1.2 million people will suffer from water shortage. The rehabilitation project will consequently benefit 1.2 million people.

### 5.7 STAFF AND TRAINING

System changes and increase in the number of staff member would be envisaged, though not a drastic ones, with the introduction of the following : 1. leakage control, 2. pipe cleaning, 3. mapping and 4. metering. Requirement of additional staff member is as follows; 7 engineers, 134 technicians, 8 surveyors/draftsmen, 26 drivers and 19 crane operators.

## 6 OPERATION/MAINTENANCE IMPROVEMENT PROGRAMME

### 6.1 REGULAR OPERATION AND MAINTENANCE WORKS

#### (1) WATER VOLUME

After the rehabilitation work in the Upper Ruvu treatment plant was completed at the end of 1990, the three treatment plants are producing water at full design capacity. NUWA has and will continue giving considerable attention to production of water.

#### (2) WATER QUALITY

1) TURBIDITY

(a) Through injection of optimal coagulation agent, all unwanted components should be eliminated from the treated water by sedimentation and filtration.
(b) By proper use of an alkaline agent, pH of the treated water should be raised to 7.5 - 8.0.
(c) The consumption of chlorine in the distribution pipeline network should be minimized. This will come consequent to implementation of the above (a), and will ensure that the necessary residual chlorine at end-use points can be maintained.

2) MTONI OPERATION

The following improvements in the plant operation is proposed; a) to initiate water quality monitoring, b) to measure flowrates and dosing rates, c) to carry out jar tests, d) to monitor and control chemical dosing, e) to log records and f) purchasing chemicals for analysis.

#### (3) PERIODICAL MEASUREMENT OF FLOW, PRESSURE AND WATER QUALITY IN DISTRIBUTION SYSTEM

Since water is scarce and further rehabilitation work will take some time, pressure control or even "time-restricted supply" in the current 24-hours-supply-areas will be an effective measure for achieving equal-supply to all consumers. To enable it to work effectively, field flow and pressure measurements at critical points in the system need to be measured and maintained regularly. Water quality, particularly residual chlorine, needs to be monitored regularly to ensure that safe potable water is being supplied.

### 6.2 LEAKAGE CONTROL

The total wastage and unaccounted for water can be assessed and controlled by systematic waste and leakage survey and detection, followed by prompt corrective action and consumer education. Such a program has to be continuous in nature; careful planning and preparatory work, plenty of time-consum-

ing and labor-intensive field surveys and intelligent investigations are required in embarking on a program of leak reduction and control.

**(1) PROCEDURE**

Leaks are of two kinds - visible, or those that are above-ground and invisible, or those that are underground. Leakage control measures should start with the former. The former can be started easily and will be very effective. Nevertheless, preparation should also start for underground leakage control simultaneously. It needs to be conducted systematically. The creation of "waste districts" covering the whole network is an effective way.

Each "waste district" should be completely "isolated hydraulically", by closing all the boundary valves, from other districts. The supply of water is allowed through a single feed pipe, on which a flow meter is fixed. The continuously recorded flow in the meter indicates wastage due to leaks in the mains. In residential areas with a 24 hour supply, minimum night flow (MNF) indicates the amount of wastage. Exact location of leaks in mains is carried out during night time, by means of sounding rods and electronic leak detectors, after the exact alignment of pipes is traced by electronic pipeline detector, as well as from the records. Also, after leakage repair, MNF is measured to confirm that the leakage drops to within an allowable degree. Leakage detection and repair is to be continued until the observed MNFs are within allowable ranges.

**(2) SCHEDULE**

To attain the target leakage level, about half the underground leaks and all the above-ground leaks must be identified and stopped by the target year. In the first year, above-ground leakage detection and repairs should start, which will take 55 months or approximately 5 years for the entire distribution area. The basic preparatory work for the underground leakage control, such as establishment of strategy, pipe drawings, procurement of equipment, waste districts establishment and training should also start in the first year. Underground leakage detection should also start in the first year, and will take 4 years to cover about the half the distribution area.

**(3) MANNING, EQUIPMENT, TOOL AND MATERIAL**

Leakage control has not been successful so far. This failure is apparently due to the fact that even passive control has not been done by a special task force, but rather under conditions similar to ordinary work like service pipe connections. Leakage control must be initiated at the engineer level at NUWA. The work must be executed as a team or organization, with daily and routine work performed by well-trained technicians monitored by engineers. Creation of a pipe inventory, formulation of "waste districts", measurements of flow and pressure etc. must accompany leakage control. Leak detection teams should be established under the direct control of NUWA DSMB. Liaison with the sub-branches must also be maintained.

Four teams need to be established for underground leakage control for a 150 km² service area in 5 years period; one team for formulation of waste districts and three teams for leakage detection and repair. Similarly, 10 teams are to be established for above-ground leakage control for all service areas in a 5 year period; five each for distribution pipes and service pipes.

### 6.3 MAPPING

Maps and drawings are vital tools for leakage control as well to record detected leak locations, and to establish and operate "waste districts", etc.

In urban areas, maps of at least 1:2,500 scale, and preferably larger, are normally considered necessary. Precise details should be recorded in 1:2,500 scale pipeline drawings. The following information is to be recorded on the maps/drawings:

i) Pipelines: schematic alignment, street name, diameter, material, age (year laid), owner's name, address, P.O.Box number and account number (if used for accounting purpose), size and number of meter (if used for accounting purpose).
ii)Valves, fire hydrants and air valves: location, diameter, type, clock-wise or anti-clock-wise direction of opening/closing.

Large-scale drawings can be utilized for accounting purposes also.

Works required to be performed first for making new pipe maps and drawings are; collection of maps, evaluation of past records and information about pipes, both formal and informal, confirmation of doubtful records and information, particularly those relating to pipe connections by trial diggings, offset survey for location of service pipes, meter boxes, taps, stand pipe and entering of pipe information onto 1:2,500 scale drawings.

Accuracy is the most important requirement for pipeline maps and drawings. Failure or delayed updating of maps and drawings can decrease their utility and reliability. Correction and updating of maps/drawings are to be made whenever new pipes are installed and repairs are made on existing pipes.

The mapping section under a Task Force needs four draftsmen each for distribution pipes and service pipes. 1 copy machine and 1 ammonia printing machine are necessary.

Making new maps and drawings start in 1991. Information will be collected from various field activities - waste district, metering, air scouring and lining. After or even during construction of new maps, their updating should be carried out.

## 6.4 METERING SYSTEM

Metering is aimed at water conservation and revenue increase. Our study shows that it will result in a 10 % reduction in high-consumed house connection.

Metering is not always practical in DSM because water pressure is too low or costs of metering are prohibitive. Accordingly, selective metering is essential for meter installation, and target areas for the metering have be chosen carefully from the start. Meters are to be installed at 15,000 "high" income households.

The water consumption, to balance costs and revenue from metering at a discount rate of 10 %, is 400 liters per capita per day. Accordingly, metering to "high" income customers is evaluated to be acceptable from the economic point of view, but it must be stressed that water billings from metering must be collected without fail.

Meters will gradually become inaccurate with time. Also, the filter provided in the water inlet of the meter will gradually be choked with silt, more so in DSM. In order for meters to function properly, regular monitoring and calibration, when needed, is necessary.

Meter reading need to be carried out regularly. The time required for a meter reading greatly depends on the relative location of houses. Ten meter readers are sufficient in the case of monthly reading and five in the case of bimonthly reading.

For 15,000 meter installation, five teams working two year are necessary (7 member/team). For meter reading, five readers are necessary for bi-monthly reading.

## 6.5 PIPE CLEANING

### (1) AIR SCOURING

Before water of an acceptable quality can be delivered to the consumer, large amounts of accumulated silt must be removed from the mains. Although flushing will remove appreciable quantities of silt, low pressures in the network mean that flushing velocities will not be high enough for effective cleaning. Among the various alternative methods for cleaning small diameter mains such as swabbing, air scouring and scraping, the air scouring method is proposed.

The equipment required is a fast towing packaged unit including air compressor, after-cooler and filtration/control unit. The size of the compressor increases with increase in pipe diameters and pipe lengths.

Air scouring needs careful planning to prevent problems such as; 1) air or dirty water entering other parts of the distribution system, 2) valves, hydrants, or wash-outs not operating correctly or not being positioned according to the distribution maps and 3) consumers complaining of the operation.

Pipes that need to be air scoured are those made of metal and less than 150 mm in diameter since 1) loose deposits are built-up in pipes with low velocity and 2) pipes that are less than 150 mm in diameter generally have low velocities in DSM. The total length of such pipes is 418 km, from the inventory of the distribution network. Such pipes are mainly cast iron pipes.

Having set up the equipment, an air scouring exercise can then be divided into four main steps:

(a) Measuring the static water pressure and setting the air pressure regulator to below the static water pressure.
(b) Driving all of the water out of the main.
(c) Setting up slug flow.
(d) Dismantling the equipment after the main has been cleaned.

The ideal air scouring team should consist of three technicians. In addition, three labourers and one driver are also required.

It is difficult to determine how much of the distribution system could be cleaned by one team. Nevertheless, it is assumed that one team could perform 1 length, i.e., 300 meters per day.

Preparatory work usually involves checking and repairing fire hydrants/valves. If one week is assumed for preparatory work at the site and air scouring itself, the time period required for about 418 km of pipeline are 27 years. To complete the air scouring exercise by 1995, six teams will be required.

### (2) SCRAPING AND LINING

Scraping will be required to remove hard encrustations in the pipe, even though this will involves excavation. Re-lining should also be carried out. Otherwise, scraping increases internal corrosion rates considerably.

Sections requiring scraping are cast iron pipes 150, 125 and 100 mm in diameter and at least 25 years old. According to the pipe inventory, the total length of pipes which have been laid before 1965 is 189 km.

One team should do only preparation work at sites, while two other teams should carry out the cleaning work.

The following are the major steps:

a) selection of the section to be lined, b) excavation and removal of pipes at the two ends of the section, c) attachment of piano wire and turning of the auger, d) initiation of scraping with winch, e) drying, f) lining, g) curing, h) disinfection work and dismantling equipment.

Two sections can be scraped and lined by one team with one machine. It is assumed to take one week for two pipe sections. One year is allocated for general preparatory work and four years for scraping and lining a total length of 189 km.

## 7 IMPROVEMENT PROGRAMME OF NUWA

### 7.1 ORGANIZATIONAL IMPROVEMENT

#### (1) INTRODUCTION

It is quite clear that both the HQ and DSMB have overall perspectives in their activities: HQ for setting national policy on planning, execution and monitoring of branch performances, which also include the DSMB, whereas DSMB is a local entity, taking care of daily operations in its assigned service area, and supplying HQ with feedback regarding its daily problem solving activities.

#### (2) LONG TERM SUGGESTIONS

In a long run, NUWA has to:

1) demarcate the boundary of jurisdiction between: a) HQ and DSMB and b) between DSMB and district water engineers of the Ministry of Water, Energy and Minerals in Kibaha and Bagamoyo.
2) establish a Branch Advisory Committee to break the ice for more cooperation with the city council of DSM which is yet free from resources constraints.
3) It would be high time that HQ gets sanction from the Ministry to oversee one of the five urban water enterprises which are to be under NUWA jurisdiction sooner or later. Our choice is Morogoro.

#### (3) SHORT TERM PROGRAMME

1) As a short term remedial measure for DSMB, whose maneuverability has been hampered by financial constraints, we would like to recommend introduction of a "revenue normalization" task force as an emergency measure, which would aim at, firstly, tackling the arrears of water bills and, secondly, finding ways to reduce the number of illegal connections.

2) Leakage control, pipe cleaning and mapping works in the rehabilitation projects of facilities will be organized into another "facilities rehabilitation" task force in order to minimize the structural impediment caused by the present organizational setup. The task force should be responsible to BM directly.

## 7.2 MANAGEMENT IMPROVEMENT

### (1) PREAMBLE

The proposals could be divided into two categories. The first consists of nostrums (water pricing policy, stopgap allowance and education of so-called work ethics) which are apt to be either overruled by the higher authorities or down for lengthy discussion before getting approved or forerun by improved working environment.

The second type of proposals could be put into practice at the discretion of NUWA alone. These proposals are focussed on improvement of the management information system and customer relationship.

### (2) WATER PRICING POLICY

The water resources must be utilized economically so that the community concerned would get optimum benefits out of them. Any water pricing policy must reflect this principle.

A combination of user-pays principle with marginal cost pricing system would be an ideal solution to satisfy those preconditions. Though there are many obstacles to the system in the prevailing reality, we have to wade into the task of establishing the best possible one.

A pricing policy must also take account of the following aspects:

a) Equity:Housekeeping money for low-income households should be taken care of at the time of decision making of the minimum charge.
b) Financial requirements: clear-cut criteria must be set up for the amount of subsidy to capital expenditures on the water authority so that it can act as the major determinant in formulating the pricing policy.
c) Consumer acceptability: the pricing system should, above all, be comprehensible to consumers.
d) Administrative costs: gains in efficiency by adopting a pricing system must always exceed the increased administrative cost incurred by doing so.
e) Environmental considerations and other governmental policies: the pricing policy should compatible with environmental consideration on the river basin from which water resources are drawn, and it should also comply with general government policies.

### (3) METERING

The fact that it is most effective in controlling consumption during both the external-to-house use and the peak period would lend metering more credibility. Hence, target areas for metering should be chosen carefully. A higher return on meter installation with, naturally, stable water supply could be expected from some areas which have been getting a windfall from the present fixed water rates.

The increasing block tariff system should be introduced to the area where meters are installed, as it is based on the marginal cost pricing system.

(4) MANAGEMENT

1) GENERAL

The only possible areas where we may at least be able to inflict damage to the vicious cycle of inadequate revenue, degenerating resources and poor services and to turn it into the virtuous cycle of good service, happy consumers and motivated staff are:

a) To convince all the employees: - that future salary raise sufficient to support his or her family could only be achieved by raising productivity, which would be the end products of their honest daily work with cost-conscious operational practices, believing in the bona fides of the management, that fair share of their efforts will be rewarded, - and that it is the right of all the employees to make use of time before and after office hours, whereas it is an offense to use equipment or materials which do not belong to them, for pecuniary gain.
b) To motivate the staff that they could be of more use to the organization

The efforts on the part of the staff of DSMB ought to be rewarded in terms of money by means of allowances. It should be independent of the basic salary scale. The amount of allowance had better be linked to the performance in reduction of arrears of bills, conversion of illegal connections to legal ones, and reduction of leakage. This will result in more satisfaction to consumers as a whole, as well as to the staff of DSMB.

2) DATABASE FOR ADMINISTRATION DEPARTMENT, DSMB

Creation of a staff database is the first step in our attempt of writing job descriptions in the distribution and its related sections, which will further facilitate our efforts to analyze jobs by providing basic information about backgrounds of the staff.

3) TASK FORCE (REVENUE NORMALIZATION)

Reduction of arrears of water bill is the primary target of the task force (TF); and conversion of illegal users into legal consumers is the secondary target.

Establishment of the TF is proposed within the framework of this project,

BM
|----- Advisory Committee (AC) to the TF
TF

The TF is to report directly to BM. At the initial stage, the key staff of the team shall consist of:

Leader: a staff from project implementation unit, directorate of planning, either an engineer or an economist.

Member: meter repair foreman, chief meter reader, a senior technician and a supply officer.

AC to the TF will consist of :

Chairman: Director of Finance.

Advisor: an expatriate management consultant with two expatriate experts, one field worker specialize in sociology, and one system analyst.

Department Heads.

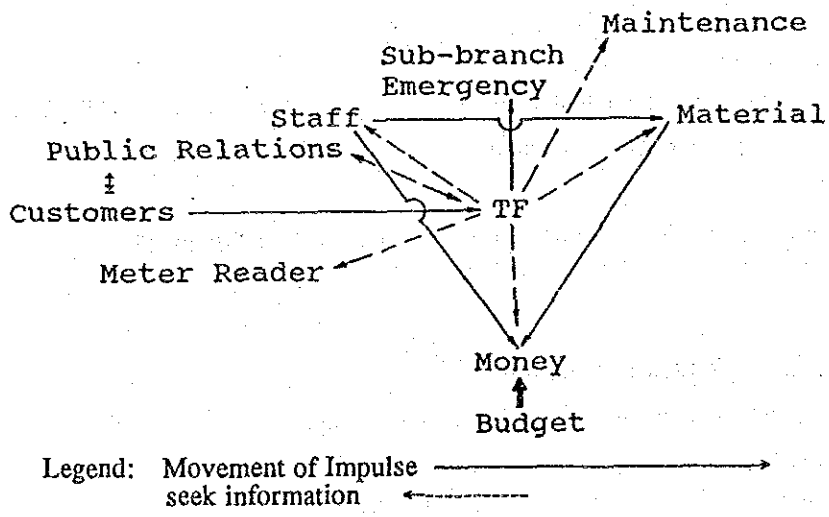
JUWATA representative of DSMB.

The TF shall daily be in contact with a certain number of householders who either have an unpaid water bill or an illegal water connection, shall see to it that the bills and penalties to illegal connection are paid and corresponding number of consumers increased, and shall put acquired information into the database.

The AC shall set the overall strategy, collect information on the target households through the sub-branch concerned, analyze socio economic, and political implications of the problems, and give the TF advises on how to approach them.

The TF operation will surely show up any bottlenecks, hidden overlaps and deficiencies in the structure of DSMB. So by-products of the TF operation will be: 1) Betterment of consumer relation and 2) Improvement in performance of routine maintenance.

**TASK FORCE IN DSMB**



4) TASK FORCE (REHABILITATION PROJECT)

A certain amount of system changes and increase in staff members is envisaged with the introduction of the following works: (a) Leakage Control, (b) Mapping, (c) Metering and (d) Pipe Cleaning

Total requirement of human resources except labourers is given below.

**REQUIREMENT OF STAFF MEMBER FOR REHABILITATION WORKS**

| | ENGINEER | TECHNICIAN | SURVEYOR/ DRAFTSMAN | DRIVER | CRANE OPERATOR |
|---|---|---|---|---|---|
| 1.Leakage control | 4 | 74 (24)*2 | 0 | 14 | 11 |
| 2.Pipe cleaning | 2 | 24 (24) | 0 | 8 | 8 |
| 3.Mapping | 1 | 0 | 8 (6) | 0 | 0 |
| 4.Metering | 0 | 36*1 (0) | 0 | 4 | 0 |
| TOTAL | 7 | 134 | 8 | 26 | 19 |

*1 including 12 meter readers.

*2 figures in ( ) shows required number of recruitment in "technician" and "surveyor/draftsmen" categorized.

## 7.3 IMPROVEMENT OF FINANCE

### (1) FINANCIAL REQUIREMENT

For the improvement of NUWA under the existing water supply system, the following are the principal measures to which special attention should be paid:

1) reduction of water production costs, 2) reduction of water losses by leakage, 3) reduction of illegal water connections, 4) reduction of bad debts, 5) meter installation and 6) tariff revision to meet financial requirements.

### (2) FINANCIAL FORECASTS OF NUWA

From 1992/93 to 1995/96, the annual tariff increase required is assumed to amount to 32 % of the level of the previous year, if the operation is to break even. The tariff increase rate is almost the same as the assumed inflation rate of 30%. The tariff increase rate required in 1991/92 amounts to 158 % (68 %; proposed tariff increase by NUWA + 90 %) against the present tariff, as the tariff revision was not approved from July 1, 1990.

### (3) FINANCIAL IMPROVEMENT PROGRAMME

The impacts of the proposed rehabilitation projects on the financial condition of NUWA DSMB have been reviewed.

#### 1) REDUCTION OF LEAKAGE AND REVENUE INCREASE

In 1995, water losses through leakage are expected to decrease from 164,000 $m^3$/day to 116,000 $m^3$/day by implementing the rehabilitation projects. Therefore, 45,000 $m^3$/day of water is saved.

#### 2) ILLEGAL CONNECTION AND BAD DEBTS

Water revenues lost due to illegal connections and bad debts are estimated at T.Shs.485 million and T.Shs.521 million, respectively, in 1990. The total revenue lost amounts to T.Shs.1,006, which is almost equivalent to the estimated deficit for NUWA to break even in 1991/92.

In 1995, the operating revenue collected from water consumption is expected to amount to T.Shs.1,140 million without the Project, while it is estimated at T.Shs.2,111 million with the Project. The collected revenue is estimated to increase by 85 % with the Project.

#### 3) FINANCIAL FORECAST WITH THE REHABILITATION PROJECT

The annual tariff increase required for NUWA to break even, would be decrease from 32 % without the Project to 20 % with the Project. It is lower than the estimated inflation, and slightly higher than the estimated increase rate of minimum wages (17 % per annum).

## 7.4 TRAINING PROGRAMME

### (1) TRAINING NEEDS

Training institutions and curricula have been well established. As far as basic technique or skill is concerned, generally speaking, all the staff have good basic training, sufficient to carry out their daily operation and maintenance duties.

Yet, there is obvious need of specific training to fill a simple form of skills gap at class rooms and on the job sites. This may suffice for the short term solution before subjects are taught at the Water Research Institute as far as trade skills are concerned. But it is quite another problem for the long-term solution.

### (2) TRAINING CONTENTS

The need to train the concerned staff will arise with the commencement of the first stage of rehabilitation projects. The training programme ought to go hand in hand with the progress of structural change of the distribution and maintenance sections. Among the four programmes to be carried out,

the repair sub-section of leakage control section, the mapping section and the meter installation work in the metering section do not require any specific courses, apart from ordinary on-the-job brush-up.

1) LEAKAGE CONTROL SECTION

Among the units in this section, two sub-units of the leakage survey unit, i.e., 1) the block formation sub-unit, which consists of a team of six members, and 2) the survey sub-unit, which is made up of three teams of six members each, need to receive training.

a) block formation sub-unit

Though the work involved is nothing but of a mundane nature, the goal of the training is to let the team members understand the concept of the block formation, how does it function, and in which way it contributes to the ultimate goal of rehabilitation.

b) survey sub-unit

On top of the above mentioned themes to be taught in the beginning of the programme for orienting young recruits, the training course for this sub-unit would provide them with full knowledge of the sensors using sound or ultra-sonic waves and other instruments and skills in operating them.
The staff of the high-tech equipment unit of the maintenance section would join this course.

2) PIPE CLEANING SECTION

The practical training course would be organized to have the team members master the use of air scouring machine and scraping and lining machines.

3) METER READER

It is the meter readers' duty to keep updating meter record. Though big errors may be canceled out by comparison of the previous records and the latest one, they are to be taught that DSMB's credibility with its customers starts from accurate meter reading.

4) MAINTENANCE SECTION

a) High-tech Equipment

The staff in charge of the unit would be trained at the manufacturers' plants on how to service the instruments. He is then to share his knowledge and skill to his selected colleagues at the DSMB's workshop.

b) Meter Shop

The meter repair foreman would get training at the manufacturer's repairing plant for two months before taking charge of the workshop at DSMB. Emphasis in the training , therefore , is placed on repairing, cleaning of internal mechanism and strainer, adjusting of gears, and testing. In the long run, manufacturing of parts will also be put on an agenda.