pipe material and installation year.

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.

In the following sections, the unacceptable conditions prevailing in the distribution and service systems observed during the study are explained and illustrated in Figure 4.13. The countermeasures proposed for comprehensive rehabilitation are also indicated in Figure 4.13. Therefore, the effect of each measure can be easily understood.

4.3.2 LOW PRESSURE AREAS

There are areas of the City receiving supplies only at night when demand in other areas drop and system pressures rise. Ground storage tanks are more common in these poorly supplied areas although the majority of properties have a single direct connection only. This is because the distribution pipe network is never fully pressurized. The service reservoirs are permanently empty, with incoming water going immediately into the network. Outlet pipes from the reservoirs flow partially full over initial lengths. This has been caused by;

1) lack of supply
2) high water demand along the transmission lines
3) high water demand in the distribution system
4) undersized main pipes, particularly in peripheral areas
5) lack of secondary and tertiary pipes
6) silt build-up and encrustation in the pipes
7) leakage and wastage

Pressure at critical points in the system were measured on January 17 and August 3, 1990 (see section 4.2, Appendix C). The pressures observed on the two days were almost the same. Day-time pressures were generally in the range of 0 - 1.5 bar (15 meters). Night-time pressures were about 1.0 bar (10 meters) higher. Figure 4.14 shows the pressure contours for the morning of January 17, 1990.

In general, water pressure is acceptable in areas near the New Bagamoyo road in the north, the Indian ocean in the east and Pugu road in the south. The hypothetical western boundary lies between Morocco/New Kigogo roads and Mandela road. These areas are urbanized areas where the secondary distribution system has been fairly well developed. More importantly, large-sized distribution mains surround the areas resulting in relatively high water pressures.

UNACCEPTABLE SITUATION	RESULTANT PROBLEM	SOLUTION
2) LACK OF DISTRIBUTION PIPE	LOW PRESSURE SUPPLY OR NO WATER SUPPLY	MAIN LAYING PROGRAMME
3) LONG SERVICE PIPE	LOW PRESSURE SUPPLY OR NO WATER SUPPLY	MAIN LAYING PROGRAMME
	LEAKAGE	LEAKAGE CONTROL
1) LOW PRESSURE OR NO PRESSURE	LOW PRESSURE SUPPLY OR NO WATER SUPPLY	MAIN LAYING PROGRAMME SYSTEM IMPROVEMENTS LEAKAGE CONTROL SYSTEM EXPANSION
6)-a LEAKAGE	LOW PRESSURE SUPPLY OR NO WATER SUPPLY	LEAKAGE CONTROL RESERVOIRS OPERATION MONITOR TRANSMISSION MAIN TAKE-OFF
4) IMPROPER PVC PIPE	LEAKAGE	- PROPER MATERIAL - PRESSURE TEST
5) SILT AND ENCRUSTATION	LOW PRESSURE SUPPLY	MAIN CLEANING REPAIR OF FILTER
6)-b ILLEGAL CONNECTION	LOW REVENUE	MAPPING (as LEAKAGE CONTROL)
7) PIPE INVENTORY	INSUFFICIENT PLANNING, OPERATION	MAPPING (as LEAKAGE CONTROL)
8) POORLY MAINTAINED VALVE	LEAKAGE	REPAIR
9) INSUFFICIENT RESIDUAL Cl_2	UNSANITARY WATER SUPPLY	WATER QUALITY MONITORING
EFFLUENT FLOW RATE CONTROLLERS	CANNOT ANALYSE OUTPUT	NEED REPAIR
NO WATER BUILD-UP IN THE RESERVOIR	LOW PRESSURE TO THE CITY	CLOSE OUTLET VALVE DURING NIGHT

FIGURE 4.13 POSSIBLE REHABILITATION PROJECTS IN DISTRIBUTION SYSTEM

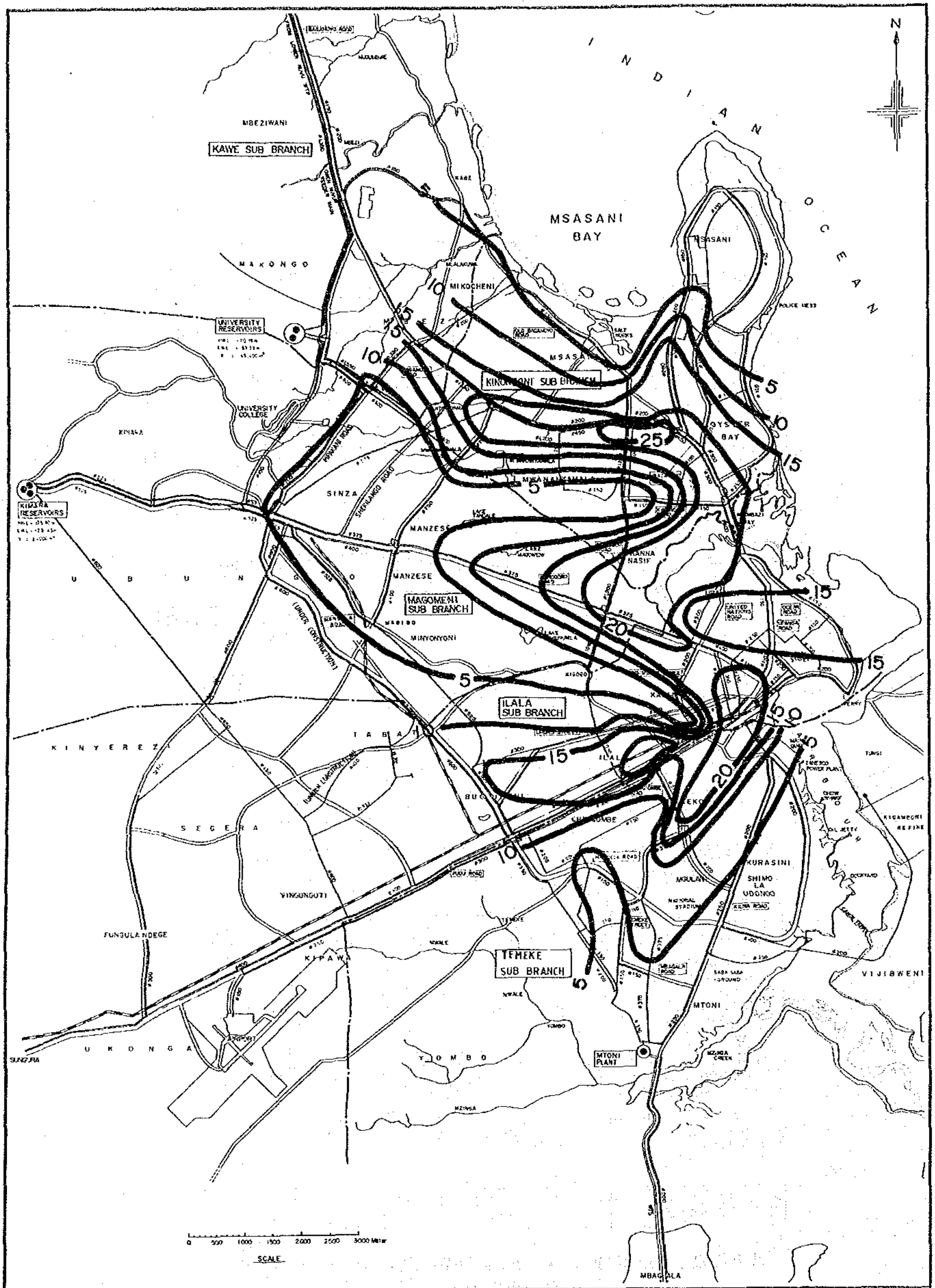

FIG. 4.14	EFFECTIVE PRESSURE CONTOUR LINES, MORNING ON JAN. 17th 1990

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

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. Hydraulic analysis (see section 5, Appendix C) of the present system confirms the above, as is shown in Figure 4.15.

Of the 11 areas identified in the hydraulic analysis, viz., 1) Oyster Bay, 3) Ubungo and Manzese, 5) Ubungo along the transmission main from Kimara reservoir, 6) Vingunguti, 7) Temeke, 9) Mtoni, 10) Mbagala and 11) also Mbagala, eight fall in the peripheral areas.

1) Inadequate pressures in the Oyster Bay area affecting distribution from nodes 121 to 127 and from 151 to 155.
2) Inadequate pressures in Kinondoni between pipe sections 115 to 141, 141 to 147, 147 to 130, 130 to 131, 147 to 148 and 148 to 149. This is mainly due to undersized pipes in these sections.
3) Inadequate pressure at nodes 103 and 114 in Ubungo and node 142 in Manzese.
4) Low pressure at nodes 133, 136, 137, 138, 139, 140, 144, 145, 156, 157, 158 and 159 affecting distribution in the Kivukoni area.
5) Inadequate pressure at node 201 in Ubungo along the transmission main from Kimara reservoir.
6) Inadequate pressure along Pugu road at Vingunguti affecting distribution at nodes 215 and 216.
7) Low pressure at key node 304, Tazara Junction, severely affecting distribution to nodes 302, 303, 308, 309, 318, 319, 320, 321, 322, 326, 327, 328 and 329 in the Temeke area.
8) Inadequate pressure along Uhuru Street affecting node 221.
9) Ineffective pumping, mainly due to a limited supply, from Mtoni source to the city resulting in low pressures at nodes 301, 310 and 331 in the Mtoni area.
10) Ineffective pumping to Mbagala resulting in adequate pressures at nodes 351 and 352.
11) Inadequately sized pumping main from Mtoni to Mbagala resulting in very high head losses along the 75 mm main to node 353.

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 consists of old cast iron pipes, there is significant hydraulic loss primarily due to tuberculation in the pipes.

Further, owing to the lack of filtration at the Lower Ruvu treatment plant, there has been a continual decline in the hydraulic efficiency and capacity of the pipe system due to extensive deposits.

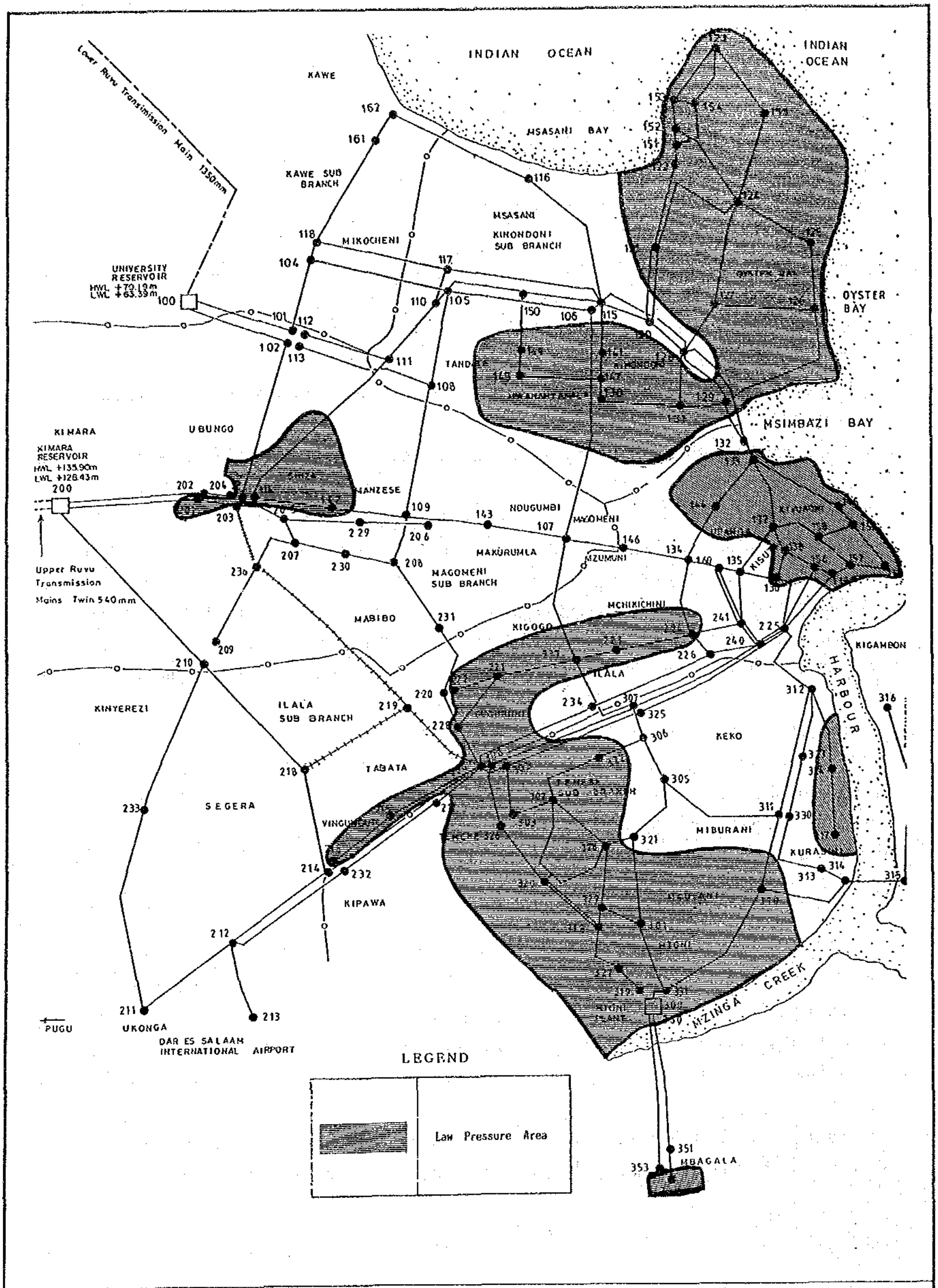

FIG. 4.15 LOW PRESSURE AREA

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

4.3.3 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.

Along the 50 km Lower Ruvu transmission pipe, approximately 20 percent of water was found to either be consumed or be lost by leakage in January 1990 (see section 4.7, Appendix C). Out of this 20 %, 7 % (about 13,000 m^3/day) was leakage and is judged to be within the allowable range. The remaining 13 % (about 27,000 m^3/day) was lost through consumption and leakage due to reasons other than off-takes (see section 4.8, Appendix C). This is much lower than those observed in Upper Ruvu, where it was as high as 83 % during the daytime and 62 % during the night. This has been attributed to the fact that different pipe materials are used in the two transmission pipes. Steel pipes are used in the Upper Ruvu, and tapping of illegal connections are easy, resulting in higher consumption through off-takes and leakage. On the other hand, illegal connection are almost non-existent in the thick prestressed concrete pipes of the Lower Ruvu pipeline. Nevertheless, transmission main leakage should be tested routinely by monitoring flows at both ends and at off-takes.

WASTAGE CONTROL

Consumption and leakage after off-takes could be reduced by cost-effective means. According to the 1988 census, 173,918 inhabitants (136,059 in 1978 census) live in Bagamoyo district, through which district the pipeline passes. Out of this total, 40,190 persons, at the most, appear to benefit from the water taken from the transmission line. This number is the total of the four wards/branches; Magomeni (13,735 persons), Dunda (9,193), Zinga and Kerege (11,287) and Yombo (5,975) - through which wards the pipeline actually passes. The amount consumed in Bagamoyo district (off-take points 1 to 9 in Figure 4.16) is 11,228 m^3/day (metered value) or 6,759 m^3/day (measured value). This represents consumption of 279 or 168 liter per capita per day, which is extremely high.

Assuming that the water service level is by yard connections, the per capita consumption should be around 85 liters per day (refer to the per capita consumption study in section 2, Appendix A). Based on this per capita consumption value, the amount consumed should only be 3,400 m^3 per day. A possible reason for this high consumption observed is that water is used for irrigation also. In order to discourage wastage, existing malfunctioning meters in the 16 off-takes should be replaced.

LEAKAGE CONTROL

In order to reduce the high pressures in the villages and the Bagamoyo town supplied from the 16 off-

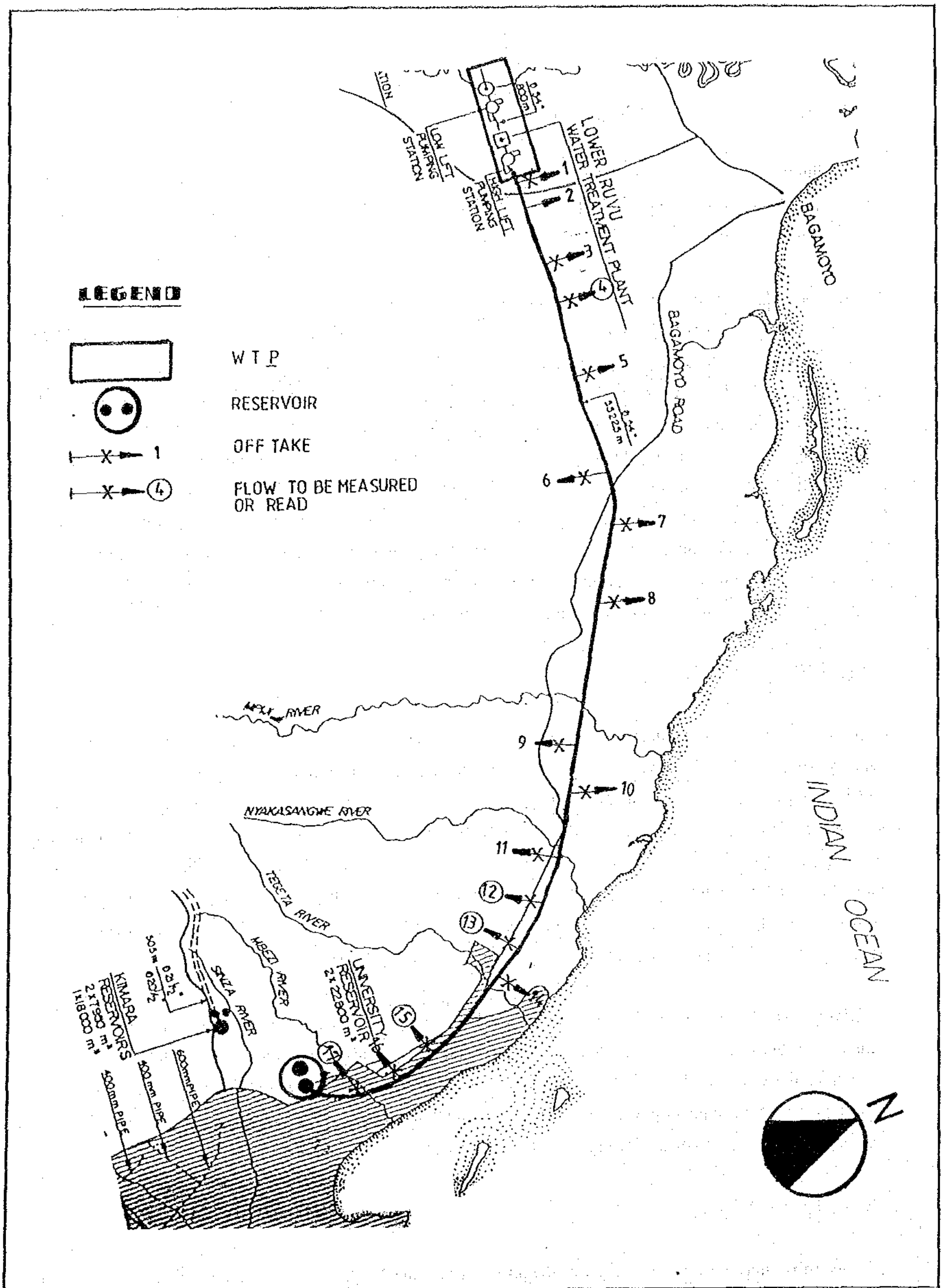

FIG. 4.16	LOCATION OF OFF-TAKES IN LOWER RUVU SYSTEM

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

takes of the Lower Ruvu system to an acceptable level, pressure reducing valves and bulk meters have been installed in every off-takes. However, most of them are not functioning properly, and pressures in the off-take are high, being in the range 60 to 100 metres. Accordingly, leakage level should exceed 50 %, judging from the 35 % leakage level in the distribution system, despite of its low pressures. Therefore, the malfunctioning pressure reducing valves should be replaced with new ones, ranging from 3" to 8" in size. It is also important that any pressure reducing valves installed are relatively maintenance free, and valves incorporating pilot valves should be avoided. Further, all off-takes should be investigated periodically to identify the nature and size of consumption.

By reduction of pressures, the existing leakage of 13,000 m^3 can be reduced by half. The amount conserved will supply approximately another 70,000 persons.

4.3.4 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 between 25% and 40% of the flow into the system. The Study team measured leakage ratios in two model areas in January, 1990 and one model area in July, 1990 and it ranges from 30% (pressure range - 5 to 23 m) to 50% (pressure range - 16 to 25 m). Details are shown in section 4.5, Appendix C.

The following factors are responsible for unaccounted for water or water lost and wasted:

1) leakage from reservoirs, pipe mains, appurtenances and service connections and wastage of water in treatment plant.
2) unauthorized or unknown use, and wastage of water through disused or abandoned connections.
3) inordinate consumption of water by consumers due to excessive use of water for gardening, washing vehicles, floor etc.
4) misuse of water for miscellaneous purposes.
5) failure to turn off taps in premises, willfully or inadvertently.
6) in intermittent supplies, emptying of stored water in a receptacle, when fresh water arrives and, keeping the tap open throughout, thus allowing water to go waste.
7) unduly high pressures in the distribution system intensifying leakage and wastage.
8) water, which is legitimately used, but not properly accounted for, e.g. at public standpipes, etc.
9) errors in measurement at any stage of production, supply and distribution.

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. The reporting can either take the form of a report of a visible leak, or a complaint of low pressure or no supply at all. No record is kept as to the types and location of leaks, the quantity of water lost and saved, and the nature of repairs.

This system has been modified so that most visible leaks are now dealt with speedily (see Table below), despite transportation problems, poor tools and old equipment. However, "first-aid" repairs are all that can be accomplished. Leak repairs are frequently carried out using rubber innertubes wrapped around the leaking pipe. These are rarely effective, and cannot withstand normal supply pressures. Hence, extensive leakage control is urgently required.

YEAR	Leaks Reported	Leaks Repaired
1984/85	848	807
1985/86	1,072	991
1986/87	1,575	1,299
1987/88	5,831	5,523

4.3.5 SILT AND ENCRUSTATION

Flushing through hydrants at relatively low velocities in February, 1990 produced brown or black water which failed to clear even after half hour of flow. 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 mostly consisted of loose deposits of silt, typically, though tuberculation was also observed. Plates 1 and 2 highlight this problem with typical examples of the condition of small diameter pipes within the distribution system.

Encrustation was measured in 25 distribution pipes with the "scale checker" (refer to section 4.4, Appendix C). All pipes except one steel pipe were cast iron pipe without internal lining. It indicated that pipe blockage and reduction in effective internal area was large in smaller diameter pipes, i.e. less than 150 mm pipe. On the other hand, there was no blockage or area reduction in large diameter pipes, i.e. diameter greater than 200 mm (the largest diameter measured was 400 mm, which was the maximum diameter that the "scale checker" can measure).

However, even if no encrustation is observed with the scale checker, much silt is expected in the pipe. Observation of some pipes revealed that there was much siltation even when no blockage was observed.

Examination of the incrustation of small diameter mains showed that the hardened incrustation of silt and rust could have been prevented, if systematic and frequent cleaning of the mains by scientific flushing methods and use of polyurethane swabs (PIG) had been practiced. Removal of silt, coupled with better treatment ensuring that no flocs and silt escape from the treatment plants, could increase the carrying capacity of the pipes, resulting in an increase in residual pressures in the tertiary system and consequently at consumer premises.

On the contrary, no external corrosion was observed and the pipes were observed to be intact on the

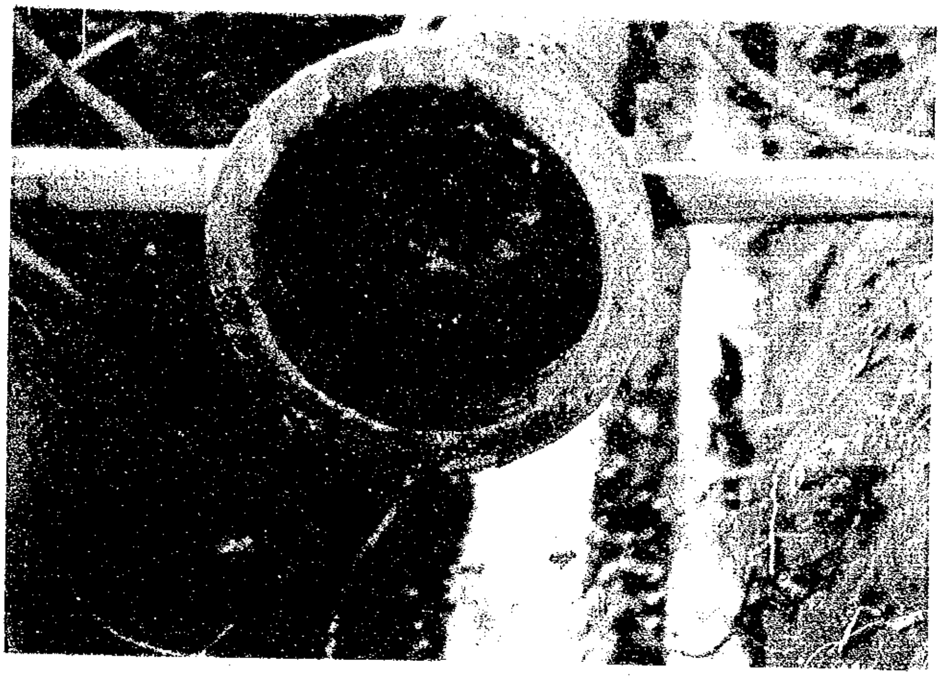

PLATE 1 PIPE INTERNAL CONDITION (1)

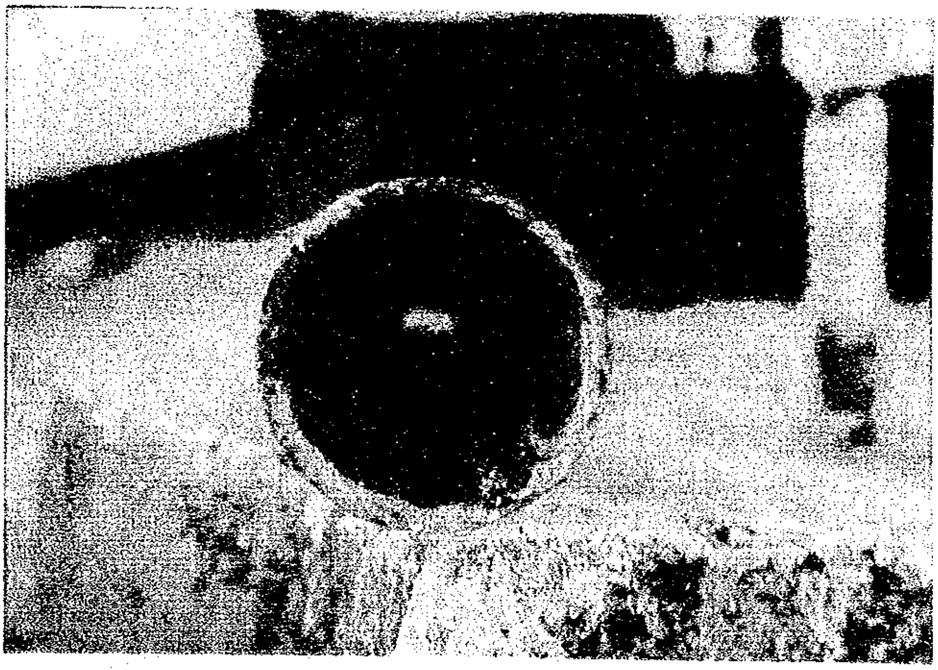

PLATE 2 PIPE INTERNAL CONDITION (2)

whole, based on inspection of 81 distribution pipes (see section 4.3, Appendix C). This means the existing pipes can be used further and pipe renewal method 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.

4.3.6 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 (refer to section 4.6, Appendix C). As a result, many disconnected pipes and closed valves were found.

Connection of existing pipes will obviously improve hydraulic efficiency of the network system. Therefore, pipe connections are proposed in strategic points.

4.3.7 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.

4.3.8 LONG SERVICE PIPE

Due to the inability of NUWA to install sufficient secondary distribution mains, an extensive network of long, small diameter service mains has 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.

4.3.9 MIDDLE ZONE

After the various measures proposed are implemented, 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. Establishment of operational zones for the distribution system, based on the three main sources at the University, Kimara and Mtoni is the most appropriate method.

Each distribution zone requires to be isolated to keep appropriate operational pressures. Water delivered from Kimara reservoir has high pressure and would better be distributed solely to high areas like the airport.

When setting up the middle zone, part of western Temeke area 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. The ground elevation in the western Temeke area is 40 to 50 meters while the low water level in the University reservoir is about 60 meters. Hence, there is a differential of only 10 to 20 meters and, considering the head loss, effective pressure is not sufficiently available in the Temeke area.

4.3.10 POORLY MAINTAINED VALVES

Valves within the network are in a state of repair. Lack of proper operation and maintenance over the years have taken their toll. Gate valves frequently leak from gland packings, especially after operations. Original packings have dried up and have deepened. Stocks of replacement material are old, if at all available. Deterioration of the internal components and frequent deposition of silt and other deposits in the pipeline means that drop tight closure of valves cannot be achieved. Fire hydrants are also frequently silted and gland packings cause leakage. Most air valves (if not all) have now been isolated from the mains to prevent leakage and therefore do not function. Many valve surfaces are damaged or missing or buried under tarmac. Spindle tubes are invariably full of silt.

4.3.11 WATER QUALITY MONITORING

Systematic and routine water quality monitoring of the distribution system as well as cleaning of the mains by flushing and swabbing is not being done on any regular basis. The quality of water supplied to the consumers through the distribution system is aesthetically unsatisfactory and occasionally, also bacteriologically unsafe. Residual chlorine is not to be found in the water supplied to the consumers in some areas.

Since no pH control is done to the treated water, the pH of the treated water is low. Output water volume fluctuates markedly, due to frequent suspension of water supply during power service interruptions leading to corrosion of the distribution pipes and release of red water. Countermeasures for these problems are given below:

(a) By using an alkaline agent, pH of the treated water should be raised to 7.5 - 8.0.

(b) By injecting the optimum amount of the agent, impurities can be removed by settling and filtration.

(c) The consumption of chlorine in the distribution network should be minimized by implementing the aforementioned measures, so that the necessary amount of residual chlorine will become available at end-use points.

4.3.12 RESERVOIR OPERATION

No build-up of water to any significant height is attempted at the University reservoir during the non-supply hours, due to the inoperability of the outlet sluice valves. This could have provided some storage and thereby improved supply to the distribution system during the peak demand period during the daytime. However, this is possibie at the Kimara reservoir.

CHAPTER 5

REHABILITATION PROJECT

CHAPTER 5 REHABILITATION PROJECT

The technical problems are identified and the technical solutions are proposed in Chapter 4. The solutions and objectives of the problems are summarized in this Chapter. Out of the solutions, measures requiring NUWA's commitment (in-house activity); improvement of operation and maintenance, leakage control measures, mapping and pipe cleaning, other than common contractual measures are described in Chapter 6.

5.1 PRINCIPLES OF REHABILITATION

Before proposing a facilities rehabilitation project, the general principles of an improvement project for DSM water supply system and NUWA are explained in this section.

5.1.1 IMPROVEMENT OF FINANCIAL CAPABILITY

(1) AUTONOMY

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. Capital investment has been covered by grants from either the central government or donor countries. However, provision of these grants have neither been timely nor adequate. As a result, even when the causes of inadequate supply have been discovered,only a few point to inadequate financial resources for capital investment. Inadequate maintenance, caused by inadequate financial resources have also shortened the life-span of the facilities.

Although continued reliance on external sources for capital investment is inevitable for some time to come, internal sources should also be vigorously explored. With internal sources, a more reliable investment project can be planned. 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. These are dealt in Chapter 7.

(2) BENEFICIARY-PAY-PRINCIPLE AND BASIC HUMAN NEEDS REQUIREMENTS

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, management of a water supply system is somewhat different from other infrastructural systems which can be managed as commercial enterprises.

Recently, a cross-subsidy structure has been introduced in water tariffs; the domestic tariff is cheaper than that for non-domestic consumption. This is aimed at better coverage of operations and maintenance costs. The next proposal is to institute a cross-subsidy system within domestic consumers, as this domestic segment constitutes a very large share in the number of connections and in the volume of water consumed. One method for this is by means of a progressively increasing unit charge system; low unit costs for consumption to satisfy basic human needs and progressively higher unit costs for consumption over and above this. Therefore, it is being proposed that meter installation be implemented for large domestic consumers, where meter installation and associated costs can be more than made up by the expected increase in revenue.

5.1.2 PROPER OPERATION AND MAINTENANCE

The following improvements in operations are essential for managing water supply systems;

1) maintain and operate pumps and treatment plants with a minimum of breakdown to avoid supply disruptions;
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 the vehicles and plants with the minimum downtime to enable the above activities to be undertaken in the shortest possible time.

Among the above measures, plant and pump operations have been improving. Maintenance of plant equipment, pumps and vehicles is essential for efficient production and distribution of water. The work is being done fairly well, despite severe financial constraints. Modifying the old adage, care and budget allocation for preventive maintenance is money better spent than that allocated for repair. Replacement of whole equipment is not cost-effective, compared to replacement of parts. Therefore, repair must be timely, without delay, as another adage aptly states - a stitch in time saves nine.

5.1.3 EQUAL DISTRIBUTION

Only after financial, organizational and managerial improvements are initiated should technical solutions be initiated. If technical solutions predate non-technical ones, technical solutions will end up as becoming merely patchwork and temporary in nature. Problems of the past will repeat itself.

Many problems have been identified in the Study. It has been discovered that only in a few areas is there adequate supply of water, 24 hours a day. Many women and children fetch water over long distances every day, due either to inadequate pressure in the existing distribution network or due to the lack of a distribution network worth its name.

Technically, the eventual goal is to supply adequate, clean and safe water efficiently at a reasonably low cost. However, this goal cannot be fulfilled immediately in DSM. Pursuing such a goal is neither economical nor practical, particularly, under the prevailing economic constraints in the country. Hence, the rehabilitation project does not intend to propose provision of piped water to all citizen, nor to supply water for 24 hours. Neither expansion in the treatment capacity nor area extension of the distribution capacity are included in the project. Implementation of the latter is useless at present. Demand has been exceeding supply by such a wide margin that expanding the distribution system alone will only redistribute water within the system; adequate supply in one area will be possible only at the cost of other areas. Expansion of treatment capacity will firstly, require a water resources study and secondly, a large outlay of capital.

As a first step, the technical goal of the 5 year rehabilitation project is to supply safe water equitably and at low-cost, postponing, for the time being, an abundant water supply.

5.2 TARGET

5.2.1 TARGET YEAR

The target date for the implementation of a rehabilitation plan should be in the near future. It cannot be in too short a period in the future, since numerous preparations need to be made for effective implementation - financial and manpower among other things. Balancing these two conflicting demands, the target year for the rehabilitation plan is set at 1995.

5.2.2 TARGET LEVEL

The fundamental problem in the DSM water supply system is inadequate supply. The conventional solution to counter this is system expansion. However, in the Study, this option has been excluded. Instead rehabilitation to the existing system is proposed. Neither inadequate facilities nor insufficient financial resources are the only cause of the current supply inadequacy, although these are the major causes.

Means for attaining sufficiency are studied first from the technical point of view. Financial, organizational and managerial aspects are also studied and presented in the following chapters.

The technical goal generally adopted is supplying adequate water in the target year, which means planning facilities from the intake to the service reservoir on a daily maximum demand basis in the target year and from a service reservoir down to consumers on an hourly maximum demand basis in the same target year. This planning is however impractical in DSM for the foreseeable future, from a simple glance at the supply and demand in the target year.

Supply cannot suffice daily maximum demand in 1995 (refer to the following section). Hence, the highest target level which can be reached is 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 project. It is possible if the leakage and wastage levels are reduced to less than 25% and nil from the current 35 % and 6 % level, respectively. This reduction will require the full commitment of NUWA, and we believe that NUWA can accomplish it. Further, this is the only practical way to supply water fairly adequately to DSM in 1995. The target level is set at supplying water on a daily average demand.

In addition, leakage control is definitely cheaper than expansion of water facilities. This is all the more so in this case, since any expansion will definitely involve water resources development. Leakage control is, among other measures, therefore essential to conserve water. It would result in availability of surplus water which can supply those currently not being served.

Increase of available water for supply will result in:
(a) increase in revenue, and
(b) deferring demand-related schemes requiring outlay of capital.

Needless to say, the set target assumes that the supplied water will be chlorinated and safe for consumption.

5.3 FRAMEWORK OF REHABILITATION PROJECT

5.3.1 SUPPLY TO THE CITY

The Mtoni system delivers its entire output directly to the distribution system. On the contrary, in the case of the Lower and the Upper Ruvu plants, the entire output is not delivered to DSM, partly because water is distributed to nearby towns and villages and partly because of leakage along the transmission lines. In the transmission lines from the Lower Ruvu plant, the current level of leakage and consumption, which is 40,000 m³/day now, is expected to reduce to 32,700 m³/day in 1995, as a result of the proposed leakage control measures (discussed later). It is assumed, that the Lower Ruvu plant will operate at its nominal capacity rather than above its capacity, as is the case at present.

At the Upper Ruvu plant, rehabilitation work was completed at the end of 1990 and, consequently, its production capacity has been restored to the design capacity of 82,000 m³/day (18 mgd). Our measurements in early 1990 showed that about 13,000 m³/day reached Kimara reservoir out of a production of about 45,000 m³/day; i.e., 32,000 m³/day is consumed or is lost to leakage along the transmission line. This consumption and leakage is assumed to remain unchanged in 1995 and 50,000 m³/day will be available for DSM after the production capacity is restored to 82,000 m³/day. Therefore, out of the combined total output, 205,900 m³/day will be available for DSM in 1995. This amount is greater than the amount available now, which is 193,400 m³/day.

TABLE 5.1 WATER SUPPLY IN 1995

Unit : m³/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 %

5.3.2 WATER DEMAND IN 1995 *

(1) POPULATION

The future population levels in DSM are estimated to determine the water demand in 1995. To project the population of DSM, it is assumed that the decrease in the population growth rate between two censual periods halves itself, i.e., the decrease in the population growth rate in a subsequent period is half the decrease experienced during the preceding period. The population levels and growth rates in the future, based on this assumption, is given in the tabulation below:

---

* Details are presented in section 1 "1995 water demand", Appendix D.

Year	Population	Intercensus Growth Rate	Decrease in Growth rate
1967 (record)	356,286		
1978 (")	843,090	7.80 %	
1988 (")	1,360,850	4.80 %	3.00 %
1998 (estimation)	1,882,800	3.30 %	1.50 %
2008 (")	2,421,900	2.55 %	0.75 %
2018 (")	3,192,200	2.18 %	0.37 %

From the above, the population growth rate in DSM is 3.30 % for the decade 1988-1998. To provide a margin of safety, a population growth rate of 3.50 % is assumed to be the annual average growth rate from 1990 to 1995. The total population of DSM in 1995 would then be 1,731,381.

(2) WATER DEMAND

In DSM, economic conditions seems to have hit the bottom and to have started rebounding, stimulated by the policy change of the Government. This will certainly increase the per capita consumption volumes.

On the other hand, reliability of the water supply and sewerage system will remain the same in terms of volume provided to customers even though this rehabilitation project intends to attain high reliability. This will conversely restrain per capita consumption from increasing. Under these circumstances, an increase in per capita consumption is not foreseen, at least by the target year 1995.

The per capita water consumption is, therefore, considered to remain at 1990 levels;

- house connection	
high	400 lpcd (liters per capita per day)
middle	250 lpcd
low	160 lpcd
- yard connection	85 lpcd
- kiosk/standpipe (no connection)	22 lpcd

It is further assumed that the proportion of house to yard to no connections within each ward in DSM would not change between 1990 and 1995. The basis for this is that while there is upgrading of the water service level with time, a large portion of the increase in the population in DSM would be migration (the other factor is natural birth - death). A large majority of the migrants from the countryside to the urban areas start city life without connections, relying on kiosks and standpipes. It is assumed that these two would largely balance out to result in a constant house to yard to no connection proportion.

TABLE 5.2 POPULATION ACCORDING TO SERVICE LEVEL IN 1995

Sub Branch	Population	Total	Population Distribution by Service Level (person)				
			House Connection			Yard Connection(%)	Kiosk/ Standpipe(%)
			High (%)	Middle (%)	Low (%)		
ILALA	426,424	393,448	25,491 (6)	25,975 (7)	90,983 (23)	71,710 (18)	179,289 (46)
TEMEKE	556,547	474,576	-------- (-)	-------- (-)	108,626 (23)	102,749 (22)	263,201 (55)
KINONDONI	196,512	196,512	53,424 (27)	-------- (-)	54,723 (28)	50,202 (26)	38,163 (19)
KAWE	118,605	46,463	--------	-------- (-)	20,908 (45)	9,293 (20)	16,262 (35)
MAGOMENI	433,293	408,340	--------	-------- (-)	107,593 (26)	113,977 (28)	186,770 (46)
TOTAL	1,731,381	1,519,339	78,915 (5)	25,975 (2)	382,833 (25)	347,931 (23)	683,685 (45)

Industrial, commercial and institutional water consumption in 1995 are assumed to increase by the GDP growth rate of last five years. Based on factors discussed above, the domestic, industrial, commercial and institutional water consumption in 1995 is given in Table 5.3. Total consumption in DSM will be 164,338 m^3/day (36 mgd) in 1995 on a daily average basis.

TABLE 5.3 WATER CONSUMPTION IN 1995

(Unit: m^3/day)

Sub Branch	Domestic	Industrial	Commercial	Institutional	Total
ILALA	42,388	1,268	3,106	2,684	49,446
TEMEKE	31,905	2,641	1,301	1,497	37,344
KINONDONI	35,233	40	1,610	657	37,540
KAWE	4,493	303	228	1,292	6,316
MAGOMENI	31,015	1,227	1,217	233	33,692
TOTAL	145,034	5,479	7,462	6,363	164,338

Water demand in 1995 will vary depending upon the leakage (and wastage) level of that year. If the leakage level in 1995 is maintained at the present level of 35 %, demand in 1995 will be (164,338 m^3/day)/(1-0.35) = 252,800 m^3/day. With this leakage level, water demand is larger than the projected supply to the city of 206,000 m^3/day on a daily average basis.

Experience shows that leakage level rises with time. If the leakage level deteriorates to 50 %, which is quite reasonable, water demand will be more than 1.5 times as high as the supply to the city, as shown in Table 5.4. On the other hand, if leakage is controllable, the projected supply can meet the projected demand on a daily average basis. This controlled level, or the so-called break-even leakage level is 25%.

TABLE 5.4 WATER DEMAND VS. LEAKAGE AND WASTAGE LEVELS IN 1995

(Unit:m³/day)

leakage level	daily average consumption total = net + wastage (level)	daily average demand	daily minimum demand	hourly maximum demand
50%	164,338=154,478+9,860 (6%)	329,000	411,000	617,000
40%	164,338=154,478+9,860 (6%)	273,000	343,000	515,000
35%	164,338=154,478+9,860 (6%)	253,000	316,000	474,000
35%	164,338=164,338+ 0 (0%)	234,000	293,000	440,000
30%	164,338=164,338+ 0 (0%)	218,000	273,000	410,000
25%	164,338=164,338+ 0 (0%)	203,000	254,000	381,000
20%	164,338=164,338+ 0 (0%)	191,000	239,000	359,000
10%	164,338=164,338+ 0 (0%)	169,000	211,000	317,000

Note : Ratio of daily maximum demand to daily average demand is 1.25.
Ratio of hourly maximum demand to daily maximum demand is 1.5.
Supply to DSM is 206,000 m³/day.

5.4 PROJECT SELECTION

5.4.1 PROJECT IDENTIFICATION

A variety of measures are identified from the following considerations;

The Mtoni treatment plant has the advantages of better raw water quality than the Ruvu river, being near the place of consumption and being near a major traffic thoroughfare, easy to operate and maintain. However, all facilities are virtually worn-out due to age. Therefore, all equipment need to be replaced. The only exceptions are the intake and the distribution pumps, which were replaced in 1989.

On the other hand, it should be remembered that its rated capacity of 6,800 m³/day is only 3 percent of the total rated capacity. Further, the major problem with this plant is with respect to the source of water. Each one of its sources have very low flow during the dry season and, therefore, there are periods during which very little water can be intaken, thereby reducing the treated throughput of the plant. Even after rehabilitation, greater yield from the various sources cannot be expected.

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

Unlike the Mtoni system, rehabilitation of the Lower Ruvu and distribution systems need to be approached from a more long-term point of view. 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. Therefore, the rehabilitation strategy is geared towards improvement of water quality and simplified operations and maintenance practices.

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

The identified measures are as follows;

Mtoni system
Repair Buza dam, repair leaking wall in coagulation basin, repair baffle wall in coagulation basin, replace sludge valve and effluent trough in clarifier, repair filter and repair chemical equipment.

Lower Ruvu system
Additional intake main, repair leakage from sludge pipe, replace low water level sensor, repair pipe in chlorinator, repair chemical equipment, repair filter and install grit chamber.

Distribution system
leakage control (transmission system), leakage control (distribution system), middle zone creation, meter installation, existing pipe connection, pipe cleaning and main pipe laying (primary and secondary).

The above measures have the following technical objectives, according to which they are classified and presented in Figure 5.1;

a) maintain or increase water available to consumers
  a)-1 increase water output or prevent decrease of water output
  a)-2 water conservation
  a)-3 improve hydraulic efficiency (carrying capacity)
b) balanced distribution
c) safe water
d) clean water
e) increase revenue and reduce cost

OBJECTIVES		COMPONENT OF REHABILITATION PROJECTS: TREATMENT SYSTEM	TRANSMISSION SYSTEM	DISTRIBUTION SYSTEM
a) keep or increase water available to consumers	a)-1 increase water output or prevent decrease of water output	* MTONI -repair Buza dam -repair leaking wall and baffle wall, coagulation basin * LOWER RUVU -additional intake main -repair leakage from sludge pipe -replace low water level sensor		
	a)-2 water conservation		-leakage control measure	-Leakage control measure -middle zone -meter installation
	a)-3 improve hydraulic efficiency (carrying capacity)			-existing pipe connection -pipe cleaning -main laying (primary) -main laying (secondary)
b) distribute with equity				-"waste district", as a leakage control measures
c) safe water		* Lower Ruvu -repair pipe in chlorinator		
d) clean water		* MTONI -replace sludge valve and effluent trough, clarifier -repair filter -repair chemical equipment * LOWER RUVU -repair chemical equipment -repair filter -grit chamber construction		-pipe cleaning
e) increase revenue and reduce cost		* Lower Ruvu -grit chamber construction		-meter installation

FIGURE 5.1 OBJECTIVES OF IDENTIFIED MEASURES

As is clear in Figure 5.1, every measures in the distribution system, once implemented, will keep or increase water amount to consumers although "pipe cleaning" and "meter installation " have simultaneously other objectives.

On the other hand, the measures for the treatment system have different objectives. They are grouped as shown below.

- Treatment Plant (water volume and safe water)
  repair leaking wall and baffle wall in coagulation basin (Mtoni), repair leakage from sludge pipe (Lower Ruvu), replace low water level sensor (Lower Ruvu), repair pipe in chlorinator (Lower Ruvu)
- Treatment Plant (prevention)
  repair Buza dam (Mtoni), additional intake main (Lower Ruvu)
- Treatment Plant (water quality - clean water)
  repair chemical equipment (Mtoni), replace sludge valve and effluent trough in clarifier (Mtoni), repair filter (Mtoni), repair chemical equipment (Lower Ruvu), repair filter (Lower Ruvu), grit chamber construction (Lower Ruvu)

Accordingly, all measures 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

5.4.2 PROJECT SELECTION

Since the project target is to supply adequate water, all measures except item j above can be selected. This selection is examined by a cost benefit analysis. However, metering is selected without the cost benefit analysis since it shows financially viability. The financial analysis is explained in section 6.4.2.

Cases considered in doing a cost benefit analysis are shown in Table 5.5, reflecting the implementation order, since the water quantity saved are governed by the order of implementation. 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 (explained below) shows that B/C ratio of case 5 exceeds 1.0 while that of case 6 does not reach to 1.0. Therefore, case 5 is selected, namely all measures in the distribution system. Measures relating to the water volume in the treatment system are also selected while those relating to the "prevention" and "water quality" are not selected. However, some measures belonging to "water quality" which is to be excluded from the above criteria, are included because they cannot function for another 5-year without urgently required minor repairs. The selected projects are listed in Table 5.6 and are shown in Figures 5.2 to 5.4.

TABLE 5.5 ECONOMIC EVALUATION OF PROJECT ALTERNATIVE CASES

MEASURE\ 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 = WITH, X = WITHOUT
* repair of the worn-out chemical equipment only in the Mtoni is included in case 5.

COST-BENEFIT ANALYSIS

Economic benefits, which would be realized from rehabilitation projects, are given as increased water consumption by distributing the water saved to users and it is measured by the consumers' willingness to pay.

SAVED VOLUME

The effect of the technical measures on the distribution system have been evaluated by hydraulic analysis using a hydraulic model (refer to section 2, Appendix D).

The projects are planned to produce and redistribute the deficit between water demand and water supply. Accordingly, 33,000 m^3/day saved by leakage control measures is an effect of the total rehabilitation projects which are the cases 5 and 6. Table 5.7 shows the amount saved by each case.

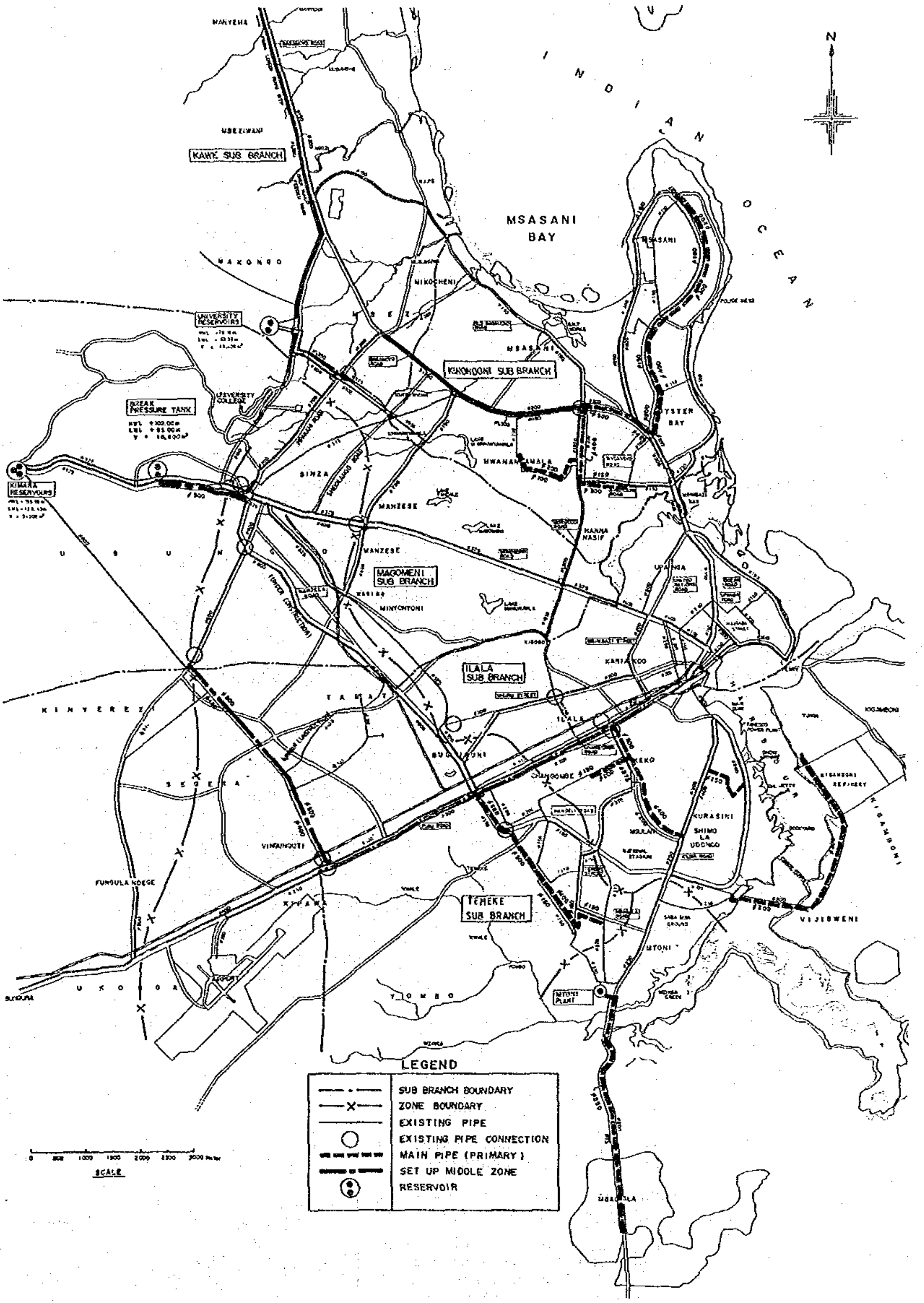

FIG. 5.2	PROPOSED REHABILITATION PROJECT - DISTRIBUTION SYSTEM (PRIMARY) -

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

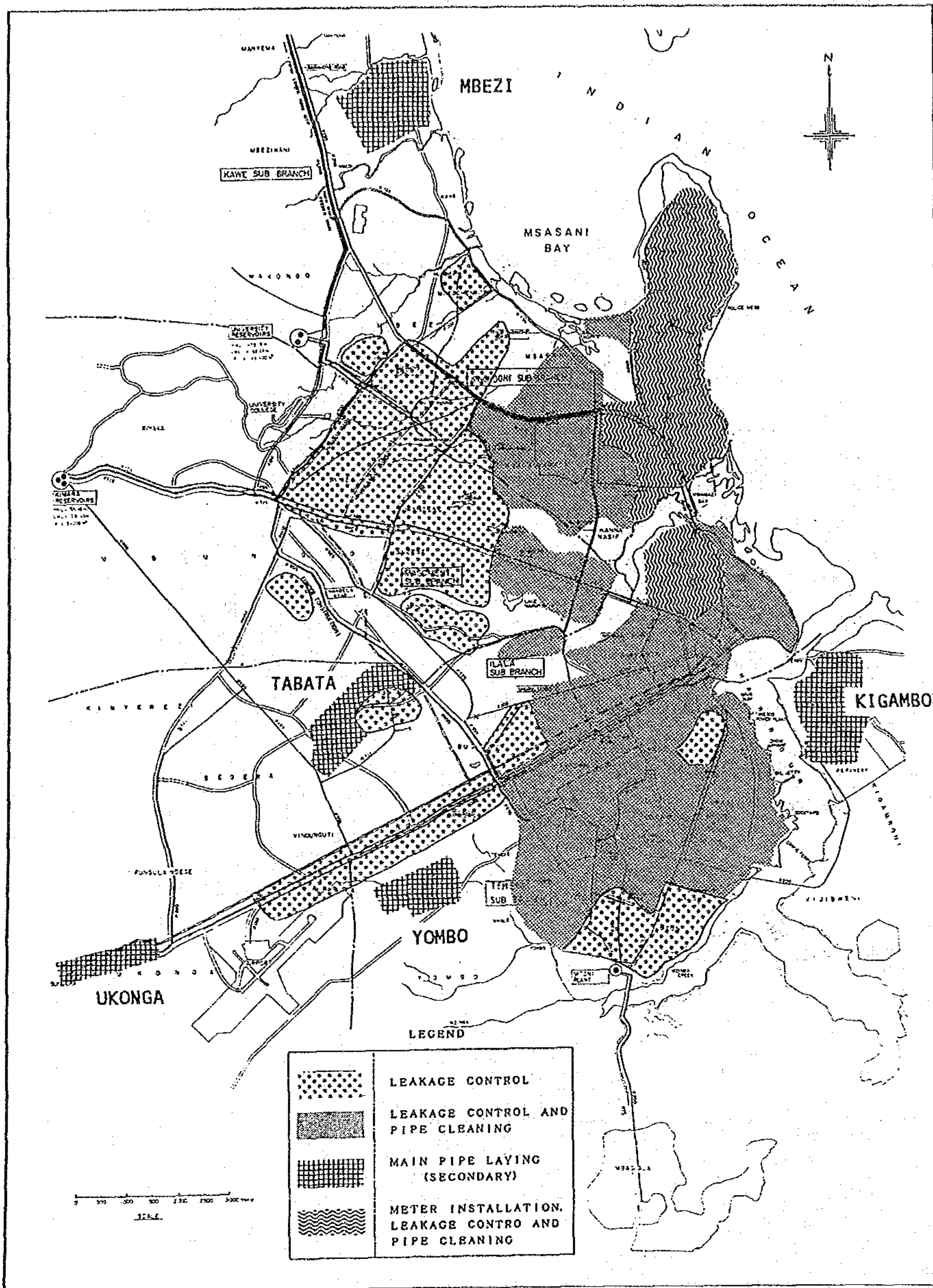

FIG. 5.3	PROPOSED REHABILITATION PROJECT - DISTRIBUTION SYSTEM (SECONDARY) -

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

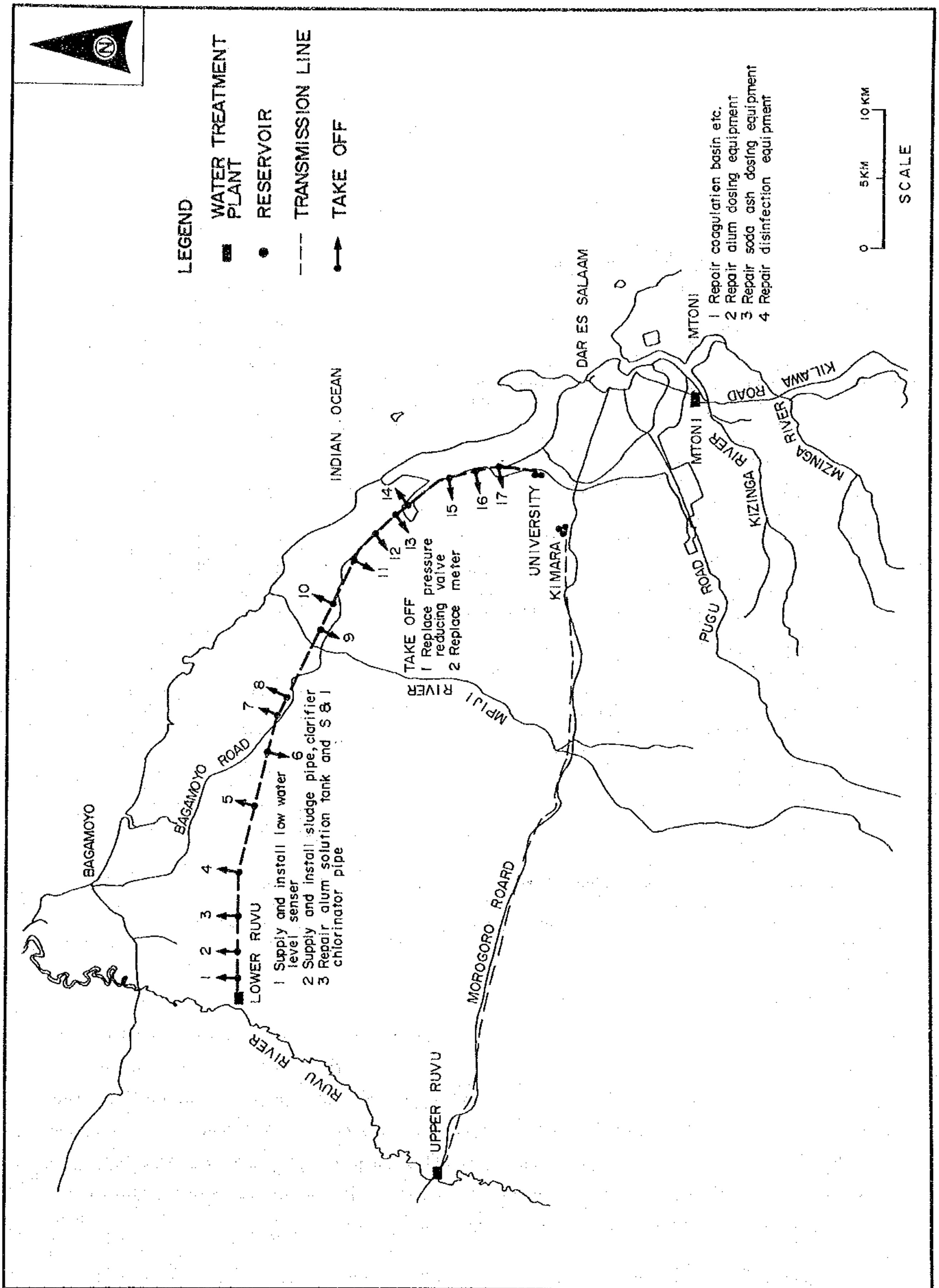

FIG. 5.4	PROPOSED REHABILITATION PROJECT - TREATMENT PLANT AND TRANSMISSION LINE -

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

TABLE 5.6 SELECTED MEASURES

Works Description	Unit	Quantity
A.IN-HOUSE ACTIVITY (CONTINUOUS WORK ITEMS)		
H1) METER INSTALLATION	each	15,000
H2)-1 LEAKAGE CONTROL MEASURE(DISTRIBUTION SYSTEM)	lump sum	1
H2)-2 MAPPING SYSTEM	lump sum	1
H3) PIPE CLEANING		
1 Air scouring	meter	417,000
2 Scraping & lining	meter	213,000
B.CONTRACTUAL WORK (NON-CONTINUOUS WORK ITEMS)		
C1) LEAKAGE CONTROL MEASURE (TRANSMISSION SYSTEM)		
1 Replace pressure reducing valve	each	16
2 Replace meter in off-takes	each	16
C2) LEAKAGE CONTROL MEASURE (DISTRIBUTION SYSTEM)		
Replace service pipe with distribution pipe	meter	90,000
C3) EXISTING PIPE CONNECTION	each	14
C4) 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
C5) 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
C6) MIDDLE ZONE		
1 Break pressure tank	m3	10,600
2 Supply and Lay Pipe at Ubungo	meter	2,800
3 Supply and Lay Pipe at Vingunguti	meter	5,000
C7) TREATMENT PLANT		
A LOWER RUVU TREATMENT PLANT		
S & I water level sensor,sludge pipe,chlorinator pipe	lump sum	1
B MTONI TREATMENT PLANT		
Repair coagulation basin and chemical equipment	lump sum	1

The amount saved by leakage control measures, including middle zone creation is estimated to be 10,300 m³/day. Unsuppressed consumption is 33,300 m³/day "without" leakage control measures, as explained above. "With" leakage control measures unsuppressed consumption is 23,000 m³/day. This 23,000 m³/day is derived from the hydraulic analysis (refer to section 2, Appendix D). Consumption where there is less than 10 meter effective pressure in the analysis is judged to be suppressed as explained in section 1 "water demand", Appendix A. Accordingly, the difference of the two figures above is estimated to be the amount saved by leakage control measures.

This, is divided into 2 components, leakage reduction in the transmission and distribution systems and leakage reduction by the middle zone, based on the estimated leakage ratio at present. As a result, the amount saved in the former (case 2) is 8,800 m³/day and that in the latter (case 5) is 1,500 m³/day. Similarly the amount saved in other cases is estimated and presented in Table 5.7.

TABLE 5.7 REHABILITATION PROJECTS ALTERNATIVES AND THEIR EFFECTIVENESS

(Unit: m³/day)

CASE	Saved Volume	Accumulated Saved Volume
CASE 1	8,800	8,800
CASE 2	10,800	19,600
CASE 3	12,200	31,800
CASE 4	1,500	33,300
CASE 5	0	33,300
CASE 6	0	33,300

* Saved volume shown in this Table, is reduction only by leakage. In addition, there is a saved volume by wastage reduction as follows; 1. 1,800, 2. 8,300, 3. 1,800. Total=11,900

Based on the above value, increased water consumption resulting from rehabilitation projects during 1991 - 1995 are given in Table 5.8.

TABLE 5.8 INCREASE IN ANNUAL WATER CONSUMPTION FOR REHABILITATION PROJECT ALTERNATIVES (SUPPRESSED) (1991 - 1995)

(Unit:Thousand m³/year)

	1991	1992	1993	1994	1995
CASE 1	642	1,186	1,927	2,570	3,212
CASE 2	1,431	2,862	4,292	5,723	7,154
CASE 3	1,431	4,322	7,249	10,176	11,607
CASE 4	1,431	4,322	7,249	10,176	12,155
CASE 5	1,431	4,322	7,249	10,176	12,155
CASE 6	1,431	4,322	7,249	10,176	12,155

In order to evaluate the economic benefits of rehabilitation projects, the following assumptions are made:

- Project life is assumed to be 20 years after the target year, as the major costs are those for pipes and fittings, whose depreciation period is 20 years.
- It is assumed that water supply, consumption and revenue after 1996 will remain at the 1995 level.
- Water tariff is based on the present tariff system, while tariff increase at the rate of 68 % is taken into account from July 1, 1991.

Increased consumers' willingness to pay is estimated as follows, reflecting the prices charged for the increased water consumption:

- Increase of water consumption by legal customers is converted to the willingness to pay, based on the estimated billings by NUWA, according to the budget for 1990/91 fiscal year.
- Increase of water consumption by illegal connections, and kiosks and standpipes is estimated, based on Demand Analysis, and is also converted to willingness to pay.
- Distribution of increased water to the four consumer groups is estimated at the same share as that of the present consumption.

The average consumers' willingness to pay for the consumption of water is calculated to be T.Shs.54.8 per m^3 (refer to Table section 6, Appendix D).

Table 5.9 shows the estimated increase of consumers' willingness to pay resulting from the rehabilitation project, of which 68 % is increase from legal consumers and the rest is from illegal, kiosk and standpipe users.

TABLE 5.9 INCREASE IN WILLINGNESS TO PAY FOR REHABILITATION PROJECT ALTERNATIVES (1991 - 1995)

(Unit: T.Shs.million/year)

	1991	1992	1993	1994	1995
CASE 1	35	65	106	141	176
CASE 2	78	157	235	314	392
CASE 3	78	237	397	558	636
CASE 4	78	237	397	558	666
CASE 5	78	237	397	558	666
CASE 6	78	237	397	558	666

PROJECT COST

The cost estimates are based on the result of the preliminary engineering design study. Table 5.10 gives the summary of the costs of the rehabilitation project for 9 measures and the detailed costs by measures are given in Table D.6.1, Appendix D.

The project costs are estimated based on the following:
- Cost estimates are based on November 1990 prices.
  Price escalation and inflation have not been considered.
- Unit price is estimated from the information given by various agencies in Tanzania and Japan, and similar study reports available.
- The exchange rate used is: T.Shs.200=US$1.00, J Yen 140=US$1.00
- Physical contingency is assumed to be 15% of the total cost.

Cost estimates by case are presented in Table 5.11.

TABLE 5.10 COST ESTIMATES OF REHABILITATION MEASURES

(Unit:T.Shs.million)

	Measure a Leakage Control (transmission)			Measure b Leakage Control (distribution)			Measure c Existing Pipe Connection			Measure d Main Pipe Laying (Primary)			Measure e Main Pipe Laying (Secondary)		
	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
1 1991	31	12	43	374	28	402	238	58	296	0	0	0	0	0	0
2 1992	0	0	0	240	36	276	0	0	0	534	121	655	0	0	0
3 1993	0	0	0	217	36	253	0	0	0	958	217	1,175	0	0	0
4 1994	0	0	0	149	36	184	0	0	0	0	0	0	121	245	366
5 1995	0	0	0	364	465	829	0	0	0	0	0	0	0	0	0
6 1996	0	0	0	170	24	194	0	0	0	0	0	0	0	0	0
7 1997	0	0	0	0	24	24	0	0	0	0	0	0	0	0	0
8 1998	0	0	0	0	24	24	0	0	0	0	0	0	0	0	0
9 1999	0	0	0	70	25	95	0	0	0	0	0	0	0	0	0
10 2000	0	0	0	0	24	24	0	0	0	0	0	0	0	0	0
11 2001	31	12	43	170	24	194	0	0	0	0	0	0	0	0	0
12 2002	0	0	0	0	24	24	0	0	0	0	0	0	0	0	0
13 2003	0	0	0	70	25	95	0	0	0	0	0	0	0	0	0
14 2004	0	0	0	0	24	24	0	0	0	0	0	0	0	0	0
15 2005	0	0	0	0	24	24	0	0	0	0	0	0	0	0	0
16 2006	0	0	0	170	24	194	0	0	0	0	0	0	0	0	0
17 2007	0	0	0	70	25	95	0	0	0	0	0	0	0	0	0
18 2008	0	0	0	0	24	24	0	0	0	0	0	0	0	0	0
19 2009	0	0	0	0	24	24	0	0	0	0	0	0	0	0	0
20 2010	0	0	0	0	24	24	0	0	0	0	0	0	0	0	0
21 2011	31	12	43	306	28	333	238	58	296	0	0	0	0	0	0
22 2012	0	0	0	171	36	207	0	0	0	534	121	655	0	0	0
23 2013	0	0	0	148	36	184	0	0	0	958	217	1,175	0	0	0
24 2014	0	0	0	149	36	184	0	0	0	0	0	0	121	245	366
25 2015	0	0	0	364	465	829	0	0	0	0	0	0	0	0	0
Salvage cost	-16	-6	-22	-777	-451	-1,228	-179	-44	-222	-1242	-281	-1,523	-109	-221	-329
Sub-total	78	30	108	2,424	1,113	3,537	298	73	370	1,743	395	2,137	133	270	403
Contingency	12	5	16	364	167	531	45	11	56	261	59	321	20	40	60
Grand total	89	35	124	2,788	1,280	4,068	342	83	426	2,004	454	2,458	153	310	463

	Measure f Pipe Cleaning			Measure g Middle Zone creation			Measure h Treatment Plant (volume)			Measure i Treatment Plant (quality & preve.)		
	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
1 1991	406	17	423	0	0	0	53	6	59	0	0	0
2 1992	53	16	69	0	0	0	0	0	0	0	0	0
3 1993	53	16	69	0	0	0	0	0	0	0	0	0
4 1994	53	16	69	0	0	0	0	0	0	0	0	0
5 1995	71	16	87	1,181	667	1,848	0	0	0	0	0	0
6 1996	269	15	283	0	0	0	22	1	23	1,273	733	2,006
7 1997	0	13	13	0	0	0	0	0	0	0	0	0
8 1998	0	13	13	0	0	0	0	0	0	0	0	0
9 1999	18	13	31	0	0	0	0	0	0	0	0	0
10 2000	0	13	13	0	0	0	0	0	0	0	0	0
11 2001	269	15	283	0	0	0	22	1	23	4	1	5
12 2002	0	13	13	0	0	0	0	0	0	0	0	0
13 2003	18	13	31	0	0	0	0	0	0	0	0	0
14 2004	0	13	13	0	0	0	0	0	0	0	0	0
15 2005	0	13	13	0	0	0	0	0	0	0	0	0
16 2006	269	15	283	0	0	0	22	1	23	4	1	5
17 2007	18	13	31	0	0	0	0	0	0	0	0	0
18 2008	0	13	13	0	0	0	0	0	0	0	0	0
19 2009	0	13	13	0	0	0	0	0	0	0	0	0
20 2010	0	13	13	0	0	0	0	0	0	0	0	0
21 2011	338	17	355	0	0	0	53	6	59	4	1	5
22 2012	53	16	69	0	0	0	0	0	0	0	0	0
23 2013	53	16	69	0	0	0	0	0	0	0	0	0
24 2014	53	16	69	0	0	0	0	0	0	0	0	0
25 2015	71	16	87	986	208	1,194	0	0	0	0	0	0
Salvage cost	-237	-11	-248	-1029	-416	-1,445	-24	-3	-27	-422	-272	-694
Sub-total	1,829	346	2,175	1,138	459	1,597	149	11	160	864	460	1,324
Contingency	274	52	326	171	69	240	22	2	24	130	69	199
Grand total	2,103	398	2,501	1,308	528	1,837	171	13	184	993	529	1,522

F.C. = Foreign currency portion, L.C. = Local currency portion

TABLE 5.11 COST ESTIMATE OF REHABILITATION PROGRAMME ALTERNATIVES

(Unit:T.Shs.million)

		CASE 1			CASE 2			CASE 3			CASE 4			CASE 5			CASE 6		
		F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
1	1991	466	46	512	740	113	852	1,207	132	1,339	1,207	132	1,339	1,268	139	1,407	1,268	139	1,407
2	1992	276	41	317	276	41	317	951	198	1,149	951	198	1,149	951	198	1,149	951	198	1,149
3	1993	249	41	291	249	41	291	1,412	309	1,721	1,412	309	1,721	1,412	309	1,721	1,412	309	1,721
4	1994	171	41	212	171	41	212	371	341	712	371	341	712	371	341	712	371	341	712
5	1995	418	535	953	418	535	953	500	553	1,053	1,858	1,320	3,178	1,858	1,320	3,178	1,858	1,320	3,178
6	1996	196	28	224	196	28	224	505	45	550	505	45	550	530	46	576	1,994	886	2,880
7	1997	0	28	28	0	28	28	0	43	43	0	43	43	0	43	43	0	43	43
8	1998	0	28	28	0	28	28	0	43	43	0	43	43	0	43	43	0	43	43
9	1999	81	28	109	81	28	109	102	43	145	102	43	145	102	43	145	102	43	145
10	2000	0	28	28	0	28	28	0	43	43	0	43	43	0	43	43	0	43	43
11	2001	231	42	273	231	42	273	541	59	599	541	59	599	566	60	625	570	61	631
12	2002	0	28	28	0	28	28	0	43	43	0	43	43	0	43	43	0	43	43
13	2003	81	28	109	81	28	109	102	43	145	102	43	145	102	43	145	102	43	145
14	2004	0	28	28	0	28	28	0	43	43	0	43	43	0	43	43	0	43	43
15	2005	0	28	28	0	28	28	0	43	43	0	43	43	0	43	43	0	43	43
16	2006	196	28	224	196	28	224	505	45	550	505	45	550	530	46	576	535	47	581
17	2007	81	28	109	81	28	109	102	43	145	102	43	145	102	43	145	102	43	145
18	2008	0	28	28	0	28	28	0	43	43	0	43	43	0	43	43	0	43	43
19	2009	0	28	28	0	28	28	0	43	43	0	43	43	0	43	43	0	43	43
20	2010	0	28	28	0	28	28	0	43	43	0	43	43	0	43	43	0	43	43
21	2011	387	46	433	661	113	773	1,049	132	1,181	1,049	132	1,181	1,111	139	1,249	1,115	139	1,255
22	2012	197	41	238	197	41	238	872	198	1,070	872	198	1,070	872	198	1,070	872	198	1,070
23	2013	171	41	212	171	41	212	1,333	309	1,642	1,333	309	1,642	1,333	309	1,642	1,333	309	1,642
24	2014	171	41	212	171	41	212	371	341	712	371	341	712	371	341	712	371	341	712
25	2015	-493	9	-484	-699	-41	-739	-2,442	-612	-3,005	-2,492	-851	-3,343	-2,492	-851	-3,343	-2,977	-1,164	-4,141
TOTAL		2,877	1,315	4,192	3,219	1,398	4,617	7,479	2,560	10,039	8,787	3,088	11,875	8,986	3,105	12,090	9,979	3,634	13,613

COMPARISON OF COSTS AND BENEFITS

Table 5.12 shows the comparison of costs and benefits (increased consumers' willingness to pay) during the project life, including the indices of economic efficiency; the net present value (NPV), the benefit cost ratio (B/C ratio) and the internal rate of return (IRR) used in conventional economic analysis.

Figure 5.5 compares the costs and benefits for the 6 cases, using a discount rate at 3 %.

The benefit cost ratio exceeds 1.0 in cases 2, 3, 4 and 5. Cases 1 and 6 are not acceptable from an economic point of view, because the benefit is lower than the cost, even using a low discount rate of 3%.

FIGURE 5.5 COMPARISON OF COSTS AND BENEFITS FOR ALTERNATIVE CASES

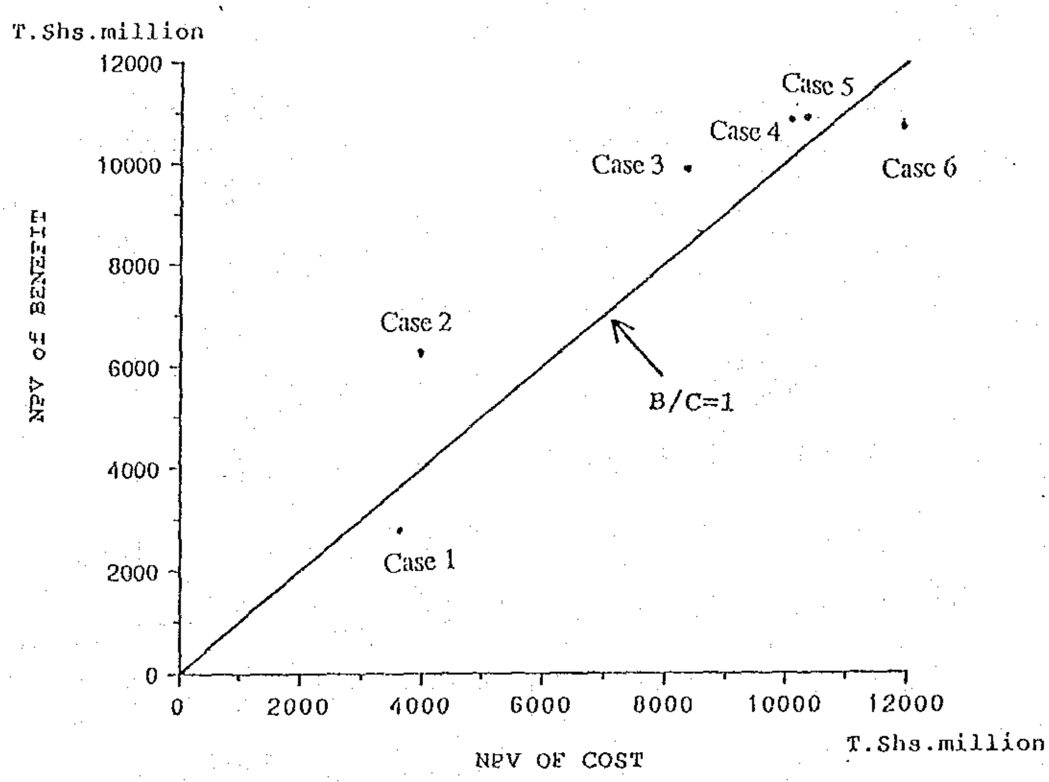

TABLE 5.12 COSTS AND BENEFITS OF REHABILITATION PROGRAMME ALTERNATIVES (1991 - 2015)

(Unit: T.Shs.million)

		CASE 1			CASE 2			CASE 3			CASE 4			CASE 5			CASE 6		
		BENEFIT	COST	PROFIT	BENEFIT	COST	PROFIT	BENEFIT	COST	PROFIT	BENEFIT	COST	PROFIT	BENEFIT	COST	PROFIT	BENEFIT	COST	PROFIT
1	1991	35	512	-477	78	852	-774	78	1,339	-1,261	78	1,339	-1261	78	1,407	-1329	78	1,407	-1329
2	1992	65	317	-252	157	317	-160	237	1,149	-912	237	1,149	-912	237	1,149	-912	237	1,149	-912
3	1993	106	291	-185	235	291	-55	397	1,721	-1,323	397	1,721	-1323	397	1,721	-1323	397	1,721	-1323
4	1994	141	212	-71	314	212	102	558	712	-154	558	712	-154	558	712	-154	558	712	-154
5	1995	176	953	-777	392	953	-561	636	1,053	-417	666	3,178	-2512	666	3,178	-2512	666	3,178	-2512
6	1996	176	224	-48	392	224	168	636	550	86	666	550	116	666	576	90	666	2,880	-2214
7	1997	176	28	148	392	28	364	636	43	594	666	43	624	666	43	624	666	43	624
8	1998	176	28	148	392	28	364	636	43	594	666	43	624	666	43	624	666	43	624
9	1999	176	109	67	392	109	283	636	145	491	666	145	521	666	145	521	666	145	521
10	2000	176	28	148	392	28	364	636	43	594	666	43	624	666	43	624	666	43	624
11	2001	176	273	-97	392	273	119	636	599	37	666	599	67	666	625	41	666	631	35
12	2002	176	28	148	392	28	364	636	43	594	666	43	624	666	43	624	666	43	624
13	2003	176	109	67	392	109	283	636	145	491	666	145	521	666	145	521	666	145	521
14	2004	176	28	148	392	28	364	636	43	594	666	43	624	666	43	624	666	43	624
15	2005	176	28	148	392	28	364	636	43	594	666	43	624	666	43	624	666	43	624
16	2006	176	224	-48	392	224	168	636	550	86	666	550	116	666	576	90	666	581	85
17	2007	176	109	67	392	109	283	636	145	491	666	145	521	666	145	521	666	145	521
18	2008	176	28	148	392	28	364	636	43	594	666	43	624	666	43	624	666	43	624
19	2009	176	28	148	392	28	364	636	43	594	666	43	624	666	43	624	666	43	624
20	2010	176	28	148	392	28	364	636	43	594	666	43	624	666	43	624	666	43	624
21	2011	176	433	-257	392	773	-381	636	1,181	-545	666	1,181	-515	666	1,249	-583	666	1,255	-589
22	2012	176	238	-62	392	238	154	636	1,070	-434	666	1,070	-404	666	1,070	-404	666	1,070	-404
23	2013	176	212	-36	392	212	180	636	1,642	-1006	666	1,642	-976	666	1,642	-976	666	1,642	-976
24	2014	176	212	-36	392	212	180	636	712	-76	666	712	-46	666	712	-46	666	712	-46
25	2015	176	-484	660	392	-739	1,131	636	-3,055	3,691	666	-3,343	4,009	666	-3,375	4,041	666	-4,173	4,839
TOTAL		4,043	4,192	-149	9,017	4,617	4,400	14627	10,039	4,589	15258	11,875	3,382	15258	12,059	3,199	15258	13,581	1,677
NPV(3%)		2,810	3,425	-615	6,270	3,828	2,442	10166	8,451	1,715	10589	10,198	392	10589	10,347	242	10589	11,952	-1,363
NPV(10%)		1,431	2,436	-1,005	3,198	2,801	397	5,174	6,325	-1,151	5,369	7,747	-2,378	5,369	7,855	-2,486	5,369	9,208	-3,839
B/C(3%)				0.82			1.64			1.20			1.04			1.02			0.89
B/C(10%)				0.59			1.14			0.82			0.69			0.68			0.58
IRR				-0.7%			13.0%			6.2%			3.6%			3.4%			1.4%

5.5 PRELIMINARY DESIGN

Preliminary designs are made for the contractual works in this section while those for the in-house works are dealt with procedures, manning requirements etc. in Chapter 6.

5.5.1 DESIGN CONDITIONS

Locally manufactured items shall conform to Tanzania Bureau of Standards (TBS). Where the TBS Specification is not published, the items should meet the requirements of the International Standards Organization (ISO). Where neither a Tanzania Standard nor an ISO Specification are available, the locally manufactured items should be in accordance with the relevant British Standard Specification.

Imported items should meet the requirements of the ISO. Where an ISO Specification is not published, the item should be in accordance with the requirements of the National Standards of the country of origin (i.e. JIS for Japanese products, DIN for German products etc.).

(1) Ductile Iron Pipe (DIP)

Ductile iron pipes are designated by ISO standard and pressure classes.

100-300mm	1.6 - 5.0 MPA
more than 300mm	1.6 - 4.0 MPA

(2) Unplasticized Polyvinyl Chloride Pipe (uPVC)

The uPVC pipe is designated by its nominal outside diameter and lettered pipe class, in accordance with Kenya standard (KS 06-149). Table 5.13 shows the outside diameter of uPVC pipes and conditions.

TABLE 5.13 uPVC SPECIFICATIONS

Items Nominal Diameter (mm)	Descriptions Outside Diameter (mm)
100	110
75	90
50	63
Water Head	5.6 kg/cm^2
Working Head	10 bar or 7.5 kg/cm^2
Standard	ISO
Joint	RR Joint

5.5.2 LEAKAGE CONTROL MEASURES FOR TRANSMISSION SYSTEM

The worn-out pressure reducing valves and water meters in 16 off-takes along the Lower Ruvu transmission line, are to be replaced with new ones, so as to reduce wastage and leakage, resulting from high pressures, in the 16 settlements.

5.5.3 REPLACEMENT OF SERVICE PIPE

This measure should allow NUWA to gradually extend the distribution network, thereby eliminating excessively long service pipes. The amount of work envisaged is estimated. Replacement of long sections of small diameter service mains is estimated to be 90,000 m in length, derived from the three model areas. The required length is 1,490 m (see Figures D.3.5 to D.3.7, Appendix), while there are 9,600 m of existing pipes in the three model areas. The ratio of the former to the latter is 0.16. Using this ratio in conjunction with the fact that the total length of the secondary pipeline is 584 km in the city, the required length is approximately 90,000 m.

TABLE 5.14 REQUIRED DISTRIBUTION PIPE EXTENSION TO REDUCE LONG, SMALL SERVICE PIPE

	Kariakoo	Magomeni	Kinondoni	Sub-Total	Dar es Salaam
Existing pipe length (meter)	4,170	2,000	3,430	9,600	583,832
Pipe required	510	480	500	1,490	90,000
Pipe required per existing pipe	0.12	0.24	0.15	0.16	0.16

5.5.4 EXISTING PIPE CONNECTION

Existing pipe connections involve repair or replacement of existing valves. The following points are proposed (node numbers are referred to Figure 4.9, chapter 4 and schematic connections in each node are shown in Figures C.4.15 and 16, Appendix C).

(1) Valves to be replaced

* Nodes 101 to 112 at BP University gasoline stand, Mwenge (825mm) and the valve is kept open
* Nodes 106 to 115 at Kinondoni junction (450mm) and kept open.
* Nodes 103 to 114 at Ubungo Junction (525mm) and kept open.
* Nodes 103 to 204 at Ubungo Junction (525mm) and kept open.
* Nodes 220 to 222 at Buguruni (300mm) and kept open.

(2) Install new connection pipe with sluice valve.

* Nodes 109 to 206 at Friendship Textile Mill Company, Manzese (400mm, double) and the valve is

kept open.

* Nodes 207 to 209 at southern part of Ubungo (600mm double)
* Nodes 214 to 215 and 214 to 232 at Kipawa, Pugu Road (400mm double and 300mm double) and kept open.
* Nodes 221 to 223 at Ilala, Uhuru Street (400mm)
* Nodes 303 to 326 at Temeke, Nelson Mandela Road (250mm)
* Nodes 307 to 325 (400mm) and 307 to 234 (300mm) at Chang'ombe,Pugu Road and the valves are kept open.
* Nodes 209 to 210 at Ubungo (600mm).

(3) Open the existing valves

* Nodes 102 to 113 at BP University gasoline stand,Mwenge (800mm)

(4) Close the existing valve

The valves between the following nodes are the boundary of the Upper and the Lower zones and it is proposed that they be kept closed although, depending on water balance in each zone, the location of some valves may need to be shifted;

* 102 and 103 (700 mm),	* 111 and 114 (525 mm),	* 109 and 142 (375 mm),
* 206 and 229 (400 mm),	* 208 and 230 (525 mm),	* 220 and 228 (450 mm),
* 221 and 228 (300 mm),	* 234 and 304 (250 mm),	* 307 and 308 (550 mm),
* 309 and 325 (300 mm),	* 302 and 322 (150 mm),	* 321 and 328 (150 mm),
* 301 and 321 (375 mm),	* 310 and 311 (250 mm),	* 310 and 314 (250 mm),
* 301 and 331 (375 mm) and	* 318 and 327 (350 mm)	

When the middle zone (discussed later in this chapter) is set up in the future, the above-mentioned boundary will become the boundary between the middle zone and the lower zone. The following valves will become boundary valves between the middle zone and the upper zone;

* 202 and 204 (525 mm),	* 201 and 203 (525 mm),
* 210 and 218 (450 mm) and	* 211 and 212 (400 mm),

5.5.5 MAIN PIPE LAYING MEASURE (PRIMARY)

Additional pipes are planned in order to improve distribution to areas identified earlier where effective pressures are less than 10 meters during hourly maximum demand periods. The areas are mostly in the outlying areas and are presented in Table 5.15 and in Figure 4.15, chapter 4 (also superimposed onto Figure C.4.17 "distribution pipe drawings", Appendix C). The planned pipe sizes can provide at least

15 meters pressure during the same periods and, the pipe routes are chosen so as to ensure the shortest possible distance from the adjacent mains.

The Vijibweni booster pump station pumps water to Vijibweni and Kigamboni areas. However, this can be abandoned when additional 12" mains are laid along the existing 8" pipe, between nodes 315 and 316. The current 8" pipe shows a very steep hydraulic gradient - 31 meters head losses for 1,000 meters length against a demand of 4,000 m^3/day. Head losses total 110 meters for a length of 3,600 meters against the pumping head of 50 meters. Installation of the 12" pipe will give an effective pressure of 19 meters at node 316 without the boosting head.

TABLE 5.15 MAIN PIPE LAYING MEASURE (PRIMARY)

Node	Major Improved Area	Pipe Diameter	Pipe Length
115 - 120	Msasani peninsular	500 mm	1,000 m
120 - 128 - 127 - 124	or Oyster bay	400	2,900
124 - 155	ditto.	300	1,300
155 - 123	ditto.	200	1,500
115 - 141 - 147 - 130	Kinondoni	400	1,600
130 - 131	ditto.	300	1,000
147 - 148 - 149	ditto.	200	2,000
304 - 326 - 320	Temeke, Mtoni	500	2,300
320 - 318 - 329 - 301	ditto.	400	2,000
307 - 306 - 305	Kurasini, Miburani	500	1,300
305 - 311 - 330	ditto.	400	1,700
323 - 324	ditto.	250	1,300
306 - 322	ditto.	200	500
313 - 314 - 315 - 316	Vijibweni, Kigamboni	300	5,100
Mtoni(350)- 351, 352, 353	Mbagala	250	5,100
400 - 203 for Middle Zone		900	2,800
210 - 218 - 214	Vingunguti, Kipawa	500	5,000
TOTAL			38,400 m

5.5.6 MAIN PIPE LAYING MEASURE (SECONDARY)

It is also proposed to establish a main pipe laying measure for secondary distribution mains and branch pipes to extend the network to new consumers once sufficient water is available.

There are areas where very little of the distribution system has been developed, particularly those in the recently developed outskirts of the city. Among them, entire areas are not selected for the short-term project, since only limited surplus water will be available. Water gained through leakage control should be diverted firstly to relatively important developed areas. Extension to all areas must await system expansion, as the investment cost required is enormous.

The five selected areas * - Mbezi, Tabata, Ukonga, Yombo and Kigamboni (see Figure 5.2) - are relatively developed and are worthwhile investing in at an early stage. Further, the selected areas are all near the existing distribution system. Therefore, it is relatively easy to extend the secondary distribution pipe network.

The selected areas have been planned in accordance with the existing conditions and future development plans, as is shown in Table 5.16. The diameters of the proposed branch lines are between 100mm to 150mm PVC pipes.

New mains to be laid must be built to a higher standard than in the past. Materials, particularly pipes, need to be of a higher quality. With proper quality control, it should be possible to locally produce pipes to an acceptable standard. It is important that integrally moulded sockets should be used where PVC pipes are laid. It is also recommended that pipe classes are over specified with a minimum specification of Class D (working pressure 120 m). Construction techniques must be improved and work must be properly supervised. Adequate pressure testing must also be performed.

TABLE 5.16 MAIN PIPE LAYING MEASURE (SECONDARY)

NAME OF AREA	SIZE OF AREA (ha)	PIPE LENGTH (meter)
TABATA	270	9,300
YOMBO	150	8,300
UKONGA	150	4,400
MBEZI BEACH	260	14,300
KIGAMBONI	190	10,500

5.5.7 MIDDLE ZONE CREATION

Establishment of operational zones for the distribution system, based on the three main sources at the University, Kimara and Mtoni is the most appropriate method. Zoning will need to be designed using the calibrated network model of the system and based on the general topography and major demand locations. Well defined zones should be capable of providing an adequate supply, with sufficient storage, at pressures of between 1.5 to 2.5 bar.

By designing the zones carefully, the need for costly and high maintenance pressure and flow regulating

---

* Areas are explained in section 3, Appendix D.

or sustaining devices can be kept to a minimum. Consideration should also be given to increase the available storage capacity for DSM by including an additional, intermediate, reservoir and establishing a new zone; creation of a middle zone between the existing Kimara (upper) zone and the University (lower) zone. The cost-benefit of providing such a reservoir should be considered and the most appropriate location chosen so as to maintain gravity flow in the system as much as possible. Each distribution zone requires to be isolated to keep appropriate operational pressures. Water delivered from Kimara reservoir has high pressure and would better be distributed solely to high areas like the airport.

Highest static pressure in the lower zone is 66 meters, while that in the upper zone reaches 108 meters. The areas with high pressure stretch from along the Mandela road with ground elevation of about 40 meters towards the west. These areas are proposed to be part of the middle zone, and separated from the Upper zone.

When setting up the middle zone, part of western Temeke area 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. The ground elevation in the western Temeke area is 40 to 50 meters while the low water level in the University reservoir is about 60 meters. Hence, there is a differential of only 10 to 20 meters and, considering the head loss, effective pressure is not sufficiently available in the Temeke area. To continue as a part of the Lower Ruvu system, other alternatives such as adding distribution mains leading to the Temeke within the lower zone and installing booster pumps will be required. But these alternatives appear uneconomical. Alternatively, the area is supplied from the Upper Ruvu system as long as surplus water is available in the Upper Ruvu system. In this case, its effective water pressure will become as high as 60 to 70 meters.

Water pressure control is necessary in the proposed middle zone to reduce the expected increase in leakage and wastage. Break pressure tanks or service reservoirs should be considered. In the long-term, new reservoirs are to be constructed for the middle zone. The high water levels of the reservoirs are to be about 100 meters, which is between the level of the two other reservoirs, 136 m and 70 meters, respectively. By doing so, the highest pressure in the middle zone can be reduced to 73 meters. By separating the middle zone from the upper zone, the highest pressure in the upper zone will also be reduced to 75 meters. Effective pressures of more than 70 meters will be reduced.

The reservoir should preferably be near the distribution mains along Morogoro road, between the Kimara reservoir and Ubungo junction, near the University reservoir, since water is taken from the Upper Ruvu system at Kimara and the additional pipes required will be short in length. The required capacity is equivalent to six hours detention time in 1995. The 2 proposed tanks should be 50 meters in length, 25 meters in width and 5 meters in side wall depth requiring 1.5 hectare of land. In connection with this, separate pipeline (refer to Figure 5.2) is required.

The break pressure tanks can be used even after water flow diverted from Kimara stops due to increased demand in the high zone. Instead, water is supplied either from the University reservoir or directly from the expanded Lower Ruvu transmission pipeline. The former needs booster pumps in the University reservoir, while the latter needs higher head than that available from expanded high-lift pumps in the Lower Ruvu plant.

The problem with the construction of a reservoir is cost. As the volume of the Kimara reservoir is 34,000 m^3, it is sufficient for a 50,000 m^3/day supply. Alternatively, cheaper pressure reducing valve can be used for the time being.

5.5.8 TREATMENT PLANT *

(1) LOWER RUVU SYSTEM

a) Reinstallation of low water level sensor in intake pumping station.

Two sets of low water level sensors are proposed to be installed in the intake pumping station
Type of sensor .... Electrode bar sensor
Number of Sensor .... Two sensors

b) Replacement of sludge drain pipe in clarifier.

Due to a lot of leakage from the existing sludge pipe, it is proposed that it be replaced with a new one to ensure proper drain of the settled sludge.

* Material of pipe .... Ductile Iron Pipe (DIP)
* Inside diameter .... 200 mm
* Proposed length .... 30 metres
* Method of installation .... Jacking method

c) Replacement of pipe in chlorinator

(2) MTONI SYSTEM

a) Repair of receiving well and coagulation basin.

* Entire wall - Painting to prevent corrosion by chemicals and patching works by steel plate to stop

---

* Drawings for repairs in the treatment plants are shown in section 3, Appendix D.

leakage from the wall.

* Baffle works - Reinstallation of baffle walls to prevent short-circuiting, in order to ensure provision of the design detention time.

b) Repair chemical dosing equipment

5.6 PROJECT COST

5.6.1 BASIC IDEA

Unit costs, obtained in November 1990, and given in section 4, Appendix D are used for a cost estimation. Major cost components are as follows:-

* Pipe material costs .... Imported
* Machine and equipment cost .... Market price in DSM
* Labour Cost .... Market price in DSM

The costs include those for the site camp, insurance, temporary work, set-up, materials testing and transport. Direct foreign currency costs include pipe and equipment costs including materials, sales tax, duty, transport, handling, storage, trenching and laying (for pipes), erection and installation (for equipment) and testing.

5.6.2 COST ESTIMATETION

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 5.17 summarizes the basic cost estimated for each rehabilitation item, broken down into foreign and local currency portions. The total estimated cost can be broken down into a foreign currency portion of T.Shs. 55 million and a local currency portion of T.Shs. 21 million.

The breakdown of the contractual and the in-house works are given in Table 5.18 and 5.19, respectively.

TABLE 5.17 TOTAL PROJECT COST

(Unit : T.Shs.million)

Measures Description	F.C.	L.C.	TOTAL
IN-HOUSE WORKS (CONTINUOUS WORKS)			
H1 Meter installation	524	15	538
H2 Leakage control measure (Distribution system) including mapping system	1,095	171	1,266
H3 Pipe cleaning	619	80	699
H4 Arrears, illegal connection	0	123	123
SUB-TOTAL	2,237	388	2,625
CONTRACTUAL WORKS (NON-CONTINUOUS WORKS)			
C1 Leakage control measure (Transmission System)	31	12	43
C2 Leakage control measure (Distribution system)	180	432	612
C3 Existing pipe connection	238	58	296
C4 Main pipe laying (primary)	1,492	338	1,830
C5 Main pipe laying (secondary)	121	245	366
C6 Middle zone	1,181	667	1,848
C7 Treatment plant	54	5	59
SUB-TOTAL	3,297	1,757	5,054
TOTAL	5,535	2,146	7,680

TABLE 5.18 PROJECT COST OF CONTRACTUAL WORKS

(Unit: T.Shs. million)

MEASURES DESCRIPTION	F.C.	L.C.	TOTAL
C1) LEAKAGE CONTROL MEASURE (TRANSMISSION LINE)			
1 Replace pressure reducing valve	24	9	33
2 Replace meter in off-takes	7	3	10
SUB TOTAL	31	12	43
C2) LEAKAGE CONTROL MEASURE (DISTRIBUTION SYSTEM)			
1 Replace service pipe with distribution pipe	180	432	612
C3) EXISTING PIPE CONNECTION	238	58	296
C4) MAIN PIPE LAYING (PRIMARY)			
1 S & L pipe at Kinondoni (400 - 200 mm)	186	43	229
2 S & L pipe at Msasani (500 - 200 mm)	348	78	426
3 S & L pipe at Temeke (500 - 400 mm)	313	67	380
4 S & L pipe at Kurasini (500 - 200 mm)	268	58	326
5 S & L pipe at Kigamboni (300 mm)	204	51	255
6 S & L pipe at Mbagala (250 mm)	173	41	214
SUB TOTAL	1,492	338	1,830
C5) MAIN PIPE LAYING (SECONDARY)			
1 S & L pipe at Mbezi	37	75	112
2 S & L pipe at Tabata	24	48	72
3 S & L pipe at Ukonga	11	23	34
4 S & L pipe at Yombo	22	44	66
5 S & L pipe at Kigamboni	27	55	82
SUB TOTAL	121	245	366
C6) MIDDLE ZONE			
1 Break pressure tank	195	459	654
2 S & L pipe at Ubungo (900 mm)	566	118	684
3 S & L pipe at Vingunguti (500 mm)	420	90	510
SUB TOTAL	1,181	667	1,848
C7) TREATMENT PLANT			
A LOWER RUVU TREATMENT PLANT	26	2	28
B MTONI TREATMENT PLANT	28	3	31
SUB TOTAL	54	5	59
TOTAL	3,297	1,757	5,054

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

TABLE 5.19 PROJECT COST OF IN-HOUSE WORKS

(Unit : T.Shs. million)

Measures	Personnel	Equipment	Operation	Material	Total
C1) METER INSTALLATION					
F.C.	0	26	0	498	524
L.C.	5	0	10	0	15
TOTAL	5	26	10	498	538
C2)-1 LEAKAGE CONTROL MEASURE (distribution system)					
F.C.	206	237	0	648	1,091
L.C.	49	0	68	47	163
TOTAL	254	237	68	695	1,254
C2)-2 MAPPING SYSTEM					
F.C.	0	4	0	0	4
L.C.	4	0	4	0	8
TOTAL	4	4	4	0	12
C3)PIPE CLEANING					
F.C.	69	287	0	263	619
L.C.	28	2	38	13	80
TOTAL	96	289	38	276	699
C4)ARREARS, ILLEGAL CONNECTION					
F.C.	0	0	0	0	0
L.C.	0	120	3	0	123
TOTAL	0	120	3	0	123
Grand-Total					
F.C.	274	554	0	1,409	2,237
L.C.	84	122	123	60	388
TOTAL	358	676	123	1,468	2,625

Note : F.C. = Foreign currency, L.C. = Local Currency portion
(at November, 1990 price level, Exchange rate
US$ 1 = T.Shs. 200 = Japanese Yen 140)

5.6.3 IMPLEMENTATION AND DISBURSEMENT SCHEDULE

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

The projects should be planned in such a way that those with high cost effectiveness are implemented first. Project selection in the sub-section 5.4.2 can serve to guide in the formulation of the order of implementation. Such an order is as follows;

1. Leakage control in the transmission line, Lower Ruvu system
2. Leakage control in the distribution system
   2.1 Wastage control
   2.2 Above-ground leakage control
   2.3 Underground leakage control
   2.4 Service pipes replacement with distribution pipe

3. Middle zone creation
4. Existing pipes connection
5. Main pipe laying (primary)
6. Main pipe laying (secondary and tertiary)
7. Connect existing pipes

Water conservation measures, i.e., items 1 and 2 above should generally precede other measures. In order to improve water supply in DSM, unaccounted-for water, including leakage and wastage needs to be decreased.

Items 1 and 2 are independent of each other and either can start first. Among the sub-item in item 2, the measures are arranged in the order of cost-effectiveness and ease of implementation. Item 2.1; wastage control and 2.2; above-ground leakage control can be easily started and resulting leakage reduction is high. Item 2.3; underground leakage control needs time-consuming preparatory works, such as making pipe drawings and construction of "waste districts". Item 2.4 may be delayed to come after item 6, since its cost-effectiveness is low.

After or during the leakage control measures, other measures such as pipe laying should start in order to distribute water adequately within the distribution system. The order of some of the measures in the above-mentioned list can be changed. Item 3 is a preventive measure against future leakage increase, and its implementation can be delayed. Item 4 can be conducted along with the leakage control measures since, it will improve hydraulic efficiency, once surplus water is produced within the distribution system.

The above discussions are applicable to conventional measures, which can be contractual works, and not to in-house works. All in-house works should commence from the beginning, since they will not only need some preparatory work but also take a long period to be implemented and to produce effects.

Pipe cleaning work should start immediately, even though cost-effectiveness is not high, since it requires a lot of preparatory work. Its immediate and direct effect is not so large, but if this is not started right from the beginning, the objectives cannot be attained by the target year. These types of work require planning, staff recruitment or relocation, training, procurement of equipment etc. in advance. Consequently, the implementation schedule is planned in Figure 5.6

The estimated costs and the implementation schedule were incorporated to prepare a project cost disbursement schedule, as given in Table 5.20. Fifteen percent was added to the basic cost as physical contingency and administrative costs. Inflation was assumed to be 5 % per annum for the foreign currency portions and 30 % for the local currency portions.

FIGURE 5.6 IMPLEMENTATION SCHEDULE

Measures	1991	1992	1993	1994	1995
A. IN-HOUSE WORKS (CONTINUOUS WORKS)					
H1) METER INSTALLATION	======	======	------	------	------
H2)-1 LEAKAGE CONTROL MEASURE(distribution system)					
-1 Establish Leakage Control Strategy	======				
-2 Prepare Pipe Drawing and Record	======	------	------	------	------
-3 Conduct Leakage Detection and Repair (Above-ground)	======	======	======	======	======
-4 Conduct Leakage Detection and Repair (Underground and Above-ground)		======	======	======	======
H2)-2 MAPPING	======	======	======	======	======
H3) PIPE CLEANING					
1 Air scouring	======	======	======	======	======
2 Scraping & lining	======	======	======	======	======
B. CONTRACTUAL WORKS (NON-CONTINUOUS WORKS)					
C1) Leakage Control Measure (transmission line)					
1 Replace pressure reducing valve	======				
2 Replace meter in off-takes	======				
C2) Leakage Control Measure (distribution system)					
Replace service pipe with distribution pipe				======	======
C3) EXISTING PIPE CONNECTION	======				
C4) MAIN PIPE LAYING (PRIMARY)					
1 S & L pipe at Kinondoni		======			
2 S & L pipe at Msasani		======			
3 S & L pipe at Temeke			======		
4 S & L pipe at Kurasini			======		
5 S & L pipe at Kigamboni			======		
6 S & L pipe at Mbagala			======		
C5) MAIN PIPE LAYING (SECONDARY)					
1 S & L pipe at Mbezi				======	
2 S & L pipe at Tabata				======	
3 S & L pipe at Ukonga				======	
4 S & L pipe at Yombo				======	
5 S & L pipe at Kigamboni				======	
C6) MIDDLE ZONE					
1 Break pressure tank					======
2 S & L pipe at Ubungo					======
3 S & L pipe at Vingunguti					======
C7) TREATMENT PLANT					
C7)-A LOWER RUVU TREATMENT PLANT					
1 S & I low water level sensor		======			
2 S & I sludge pipe in clarifier	======				
3 S & I chlorinator pipe	======				
C7)-B MTONI TREATMENT PLANT					
1 Repair leaking wall, chemical equipment	======				

TABLE 5.20 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)

TABLE 5.21 DISBURSEMENT SCHEDULE (CONTRACTUAL WORKS)

(Unit : T.Shs. million)

MEASURES DESCRIPTION	Unit	Quan-tity	TOTAL			1991			1992			1993			1994			1995		
			F.C.	L.C.	TOTAL	F.C.	L.C.	S.T.	F.C.	L.C.	S.T.	F.C.	L.C.	S.T.	F.C.	L.C.	S.T.	F.C.	L.C.	S.T.
1) LEAKAGE CONTROL MEASURE (TRANSMISSION LINE)																				
1 Replace pressure reducing valve	each	16	24	9	33	24	9	33												
2 Replace meter in off-takes	each	16	7	3	10	7	3	10												
SUB TOTAL			31	12	43	31	12	43												
2) LEAKAGE CONTROL MEASURE(DISTRIBUTION SYSTEM)																				
1 Replace service pipe with distribution pipe	m	90,000	180	432	612													180	432	612
3) EXISTING PIPE CONNECTION	each	14	238	58	296	238	58	296												
4) MAIN PIPE LAYING (PRIMARY)																				
1 S & L pipe at Kinondoni 400 - 200 mm	m	4,600	186	43	229				186	43	229									
2 S & L pipe at Msasani 500 - 200 mm	m	6,700	348	78	426				348	78	426									
3 S & L pipe at Temeke 500 - 400 mm	m	4,300	313	67	380							313	67	380						
4 S & L pipe at Kurasini 500 - 200 mm	m	4,800	268	58	326							268	58	326						
5 S & L pipe at Kigamboni 300 mm	m	5,100	204	51	255							204	51	255						
6 S & L pipe at Mbagala 250 mm	m	5,100	173	41	214							173	41	214						
SUB TOTAL			1492	338	1830				534	121	655	958	217	1175						
5) MAIN PIPE LAYING (SECONDARY)																				
1 S & L pipe at Mbezi	m	14,300	37	75	112										37	75	112			
2 S & L pipe at Tabata	m	9,300	24	48	72										24	48	72			
3 S & L pipe at Ukonga	m	4,400	11	23	34										11	23	34			
4 S & L pipe at Yombo	m	8,300	22	44	66										22	44	66			
5 S & L pipe at Kigamboni	m	10,500	27	55	82										27	55	82			
SUB TOTAL			121	245	366										121	245	366			
6) MIDDLE ZONE																				
1 Break pressure tank	m^3	10,600	195	459	654													195	459	654
2 S & L pipe at Ubungo 900 mm	m	2,800	566	118	684													566	118	684
3 S & L pipe at Vingunguti 500 mm	m	5,000	420	90	510													420	90	510
SUB TOTAL			1181	667	1848													181	667	1848
7) TREATMENT PLANT																				
LOWER RUVU TREATMENT PLANT			26	2	28	26	2	28												
MTONI TREATMENT PLANT			28	3	31	28	3	31												
SUB TOTAL			54	5	59	54	5	59												
T O T A L (1 -- 7)			3297	1757	5054	323	75	398	534	121	655	958	217	1175	121	245	366	1361	1099	2460
PHYSICAL CONTINGENCY			494	263	757	48	11	59	80	18	98	144	32	176	18	37	55	204	165	369
PRICE CONTINGENCY			718	4000	4718	19	26	45	63	96	159	174	298	472	30	523	553	432	3057	3489
G R A N D T O T A L			4509	6020	10529	389	112	501	678	235	913	1275	547	1822	169	805	974	1997	4321	6318

Note : F.C.= Foreign currency portion, L.C.= Local currency portion S & I = supply and install, S & L = supply and lay, l.s. = lump sum
(1 US$ = T.Shs.200 = Japanese Yen 140, at November, 1990)

TABLE 5.22 DISBURSEMENT SCHEDULE (IN-HOUSE WORKS)

(Unit : T.Shs. million)

Measures	Total*1 F.C.	Total*1 L.C.	Total*1 TOTAL	1991 F.C.	1991 L.C.	1991 TOTAL	1992 F.C.	1992 L.C.	1992 TOTAL	1993 F.C.	1993 L.C.	1993 TOTAL	1994 F.C.	1994 L.C.	1994 TOTAL	1995 F.C.	1995 L.C.	1995 TOTAL	1995 (Replace) F.C.	1995 (Replace) L.C.	1995 (Replace) TOTAL
1) METER INSTALLATION																					
(1)Labor	0	5	5		1	1		1	1		1	1		1	1		1	1			0
(2)Machine Parts	26	0	26	25	0	25	1		1			0			0			0	10	0	10
(3)Maintenance	0	10	10		2	2		2	2		2	2		2	2		2	2			0
(4)Material	498	0	498	249		249	249		249			0			0			0			0
Sub-Total	524	15	538	274	3	277	250	3	253	0	3	3	0	3	3	0	3	3	10	0	10
2)-1 LEAKAGE CONTROL MEASURE																					
(1)Labor	206	49	254	69	10	78	69	10	78	69	10	78		10	10		10	10			0
(2)Machine Parts	237	0	237	237	0	237			0			0			0			0	66	0	66
(3)Maintenance	0	68	68		14	14		14	14		14	14		14	14		14	14			0
(4)Material	648	47	695	66	3	69	172	12	183	149	12	160	149	12	161	114	9	122			0
Sub-Total	1,091	163	1,254	371	27	397	240	35	275	217	35	252	149	35	184	114	32	145	66	0	66
2)-2 MAPPING SYSTEM																					
(1)Labor	0	4	4		1	1		1	1		1	1		1	1		1	1			0
(2)Machine Parts	4	0	5	4	0	5			0			0			0			0	4	0	5
(3)Maintenance	0	4	4		1	1		1	1		1	1		1	1		1	1			0
(4)Material	0	0	0			0			0			0			0			0			0
Sub-Total	4	8	12	4	2	6	0	2	2	0	2	2	0	2	2	0	2	2	4	0	5
3) PIPE CLEANING																					
(1)Labor	69	28	96	69	6	74		6	6		6	6		6	6		6	6			0
(2)Machine Parts	287	2	289	287	2	289			0			0			0			0	18		18
(3)Maintenance	0	38	38		8	8		8	8		8	8		8	8		8	8			0
(4)Material	263	13	276	51	2	53	53	3	56	53	3	56	53	3	56	53	3	56			0
Sub-Total	619	80	699	407	17	424	53	16	69	53	16	69	53	16	69	53	16	69	18	0	18
4) ARREARS, ILLEGAL CONNECTION																					
(1)Labor	0	0	0			0			0			0			0			0			0
(2)Machine Parts	0	120	120		24	24		24	24		24	24		24	24		24	24			0
(3)Maintenance	0	3	3		1	1		1	1		1	1		1	1		1	1			0
(4)Material	0	0	0			0			0			0			0			0			0
Sub-Total	0	123	123	0	25	25	0	25	25	0	25	25	0	25	25	0	25	25	0	0	0
SUB TOTAL																					
(1)Labor	274	84	358	137	17	154	69	17	85	69	17	85	0	17	17	0	17	17	0	0	0
(2)Machine Parts	554	122	676	553	26	580	1	24	25	0	24	24	0	24	24	0	24	24	98	1	99
(3)Maintenance	0	123	123	0	25	25	0	24	24	0	24	24	0	24	24	0	24	24	0	0	0
(4)Material	1,409	60	1,468	365	6	371	474	14	488	202	14	216	202	14	216	167	11	178	0	0	0
Sub-Total	2,237	388	2,625	1,056	74	1,129	543	80	622	270	80	350	202	80	281	167	76	243	98	1	99
PHYSICAL CONTINGENCY	336	58	394	158	11	170	81	12	93	41	12	53	30	12	42	25	11	36	15	0	15
PRICE CONTINGENCY	276	608	888	61	26	87	64	63	129	48	110	159	50	171	222	53	238	291	31	3	34
GRAND TOTAL	2,849	1,056	3,907	1,275	111	1,386	688	155	844	359	202	562	282	263	545	245	325	570	144	4	148

Note : *1 Except Replace Parts in 1995.
F.C.= Foreign currency portion, L.C.= Local currency portion S & I = supply and install, S & L = supply and lay, l.s. = lump sum
(1 US$ = T.Shs.200 = Japanese Yen 140, at November, 1990)

5.7 PROJECT EVALUATION

5.7.1 FINANCIAL ANALYSIS

(1) FRAMEWORK

The principle objective of financial analysis is to evaluate the financial viability of the proposed projects and clarify the effect of the investment on the financial position of NUWA, DSMB.

The proposed rehabilitation project consists of the facility rehabilitation projects, meter installation and administrative improvement programmes (reduction of arrears and illegal connections). The projects have been evaluated as following.

It has been primarily examined whether the revenues generated from implementation of the proposed facility improvement projects and meter installation cover the investment costs of the project including operations and maintenance costs. Secondly, revenue increase through administrative improvement programmes has been evaluated in order to clarify the financial viability of the proposed projects. Furthermore, financing by means other than from project revenue has also been reviewed.

The financial efficiency of meter installation has been evaluated in Chapter 6 (refer to 6.4.2).

The proposed rehabilitation project is intended to be implemented over a period of five years, ending in 1995. Tables 5.23 and 5.24 give the costs schedules of the projects, including operations and maintenance costs, and physical contingency which is estimated to be 15 % of the total costs.

(2) ASSUMPTIONS

The following assumptions have been made to evaluate the project:

- Project costs have been estimated at November 1990 market prices.
- For revenue estimation, the revised tariff including the proposed 68 % increase from July 1, 1991 is assumed.
- Project term is assumed to be 20 years, after the target year when rehabilitation projects will be completed.
- Physical contingency is assumed to be 15% of the total costs.
- Inflation has not been taken into account both for revenue and for expenditure projections in financial analysis. However, for the present financial plan, inflation has been estimated at 5 % for the foreign currency portion and 30% for the local currency portion.

- Depreciation has been calculated according to NUWA regulations. Depreciation schedule is given in Table D.6.2, Appendix D. Replacement costs after the depreciation period are included in the estimates.
- The salvage value (undepreciated value) is assumed as a negative cost in the final year of the project life.
- Income tax has not been taken into account, because NUWA is exempted from paying income tax.

Comparison of "With and Without Project" is used to evaluate the Project. Water demand, suppression factors, suppressed consumption, water billings and collected revenues "Without the Project" and "With the Project" are assessed in Table D.6.3, Appendix D.

TABLE 5.23 COST ESTIMATE OF PROPOSED PROGRAMMES

(Unit: T.Shs.million)

	GRAND TOTAL			REHABILITATION PROJECT (FACILITY)			METER INSTALLATION			ADMINISTRATIVE IMPROVEMENT		
	F.C.	L.C.	TOTAL	F.C.	L.C.	TOTAL	F.C.	L.C.	TOTAL	F.C.	L.C.	TOTAL
1 1991	1,585	170	1,755	1,268	139	1,407	315	3	318	2	28	30
2 1992	1,238	229	1,467	951	198	1,149	287	3	290	0	28	28
3 1993	1,412	340	1,752	1,412	309	1,721	0	3	3	0	28	28
4 1994	371	372	743	371	341	712	0	3	3	0	28	28
5 1995	1,869	1,351	3,220	1,858	1,320	3,178	11	3	14	0	28	28
6 1996	550	77	627	530	46	576	18	3	21	2	28	30
7 1997	1	74	74	0	43	43	1	3	4	0	28	28
8 1998	0	74	74	0	43	43	0	3	3	0	28	28
9 1999	113	74	187	102	43	145	11	3	14	0	28	28
10 2000	0	74	74	0	43	43	0	3	3	0	28	28
11 2001	872	91	963	566	60	625	304	3	307	2	28	30
12 2002	287	74	361	0	43	43	287	3	290	0	28	28
13 2003	113	74	187	102	43	145	11	3	14	0	28	28
14 2004	0	74	74	0	43	43	0	3	3	0	28	28
15 2005	0	74	74	0	43	43	0	3	3	0	28	28
16 2006	550	77	627	530	46	576	18	3	21	2	28	30
17 2007	113	74	187	102	43	145	12	3	15	0	28	28
18 2008	0	74	74	0	43	43	0	3	3	0	28	28
19 2009	0	74	74	0	43	43	0	3	3	0	28	28
20 2010	0	74	74	0	43	43	0	3	3	0	28	28
21 2011	1,428	170	1,597	1,111	139	1,249	315	3	318	2	28	30
22 2012	1,159	229	1,388	872	198	1,070	287	3	290	0	28	28
23 2013	1,333	340	1,673	1,333	309	1,642	0	3	3	0	28	28
24 2014	371	372	743	371	341	712	0	3	3	0	28	28
25 2015	1,645	823	2,468	1,634	792	2,426	11	3	14	0	28	28
Salvage cost	-4,476	-1,647	-6,123	-4,153	-1,647	-5,801	-323	0	-323	0	0	0
TOTAL	10,532	3,880	14,412	8,958	3,101	12,059	1,562	83	1,645	12	696	707

TABLE 5.24 COST ESTIMATE OF PROPOSED PROGRAMMES BY DEPRECIATION PERIOD

(Unit: T.Shs.million)

	GRAND TOTAL			TOTAL OF CAPITAL COST			TOTAL OF O&M COST			BUILDING			PIPE & FITTINGS		
	F.C.	L.C.	TOTAL	F.C.	L.C.	TOTAL	F.C.	L.C.	TOTAL	F.C.	L.C.	TOTAL	F.C.	L.C.	TOTAL
1 1991	1,585	170	1,755	1,585	96	1,681	0	75	75	0	0	0	443	78	522
2 1992	1,238	229	1,467	1,238	156	1,393	0	74	74	0	0	0	872	156	1,028
3 1993	1,412	340	1,752	1,412	266	1,678	0	74	74	0	0	0	1,333	266	1,599
4 1994	371	372	743	371	298	669	0	74	74	0	0	0	371	298	669
5 1995	1,869	1,351	3,220	1,869	1,277	3,146	0	74	74	224	528	752	1,532	749	2,281
6 1996	550	77	627	550	3	553	0	74	74	0	0	0	0	0	0
7 1997	1	74	74	1	0	1	0	74	74	0	0	0	0	0	0
8 1998	0	74	74	0	0	0	0	74	74	0	0	0	0	0	0
9 1999	113	74	187	113	1	113	0	74	74	0	0	0	0	0	0
10 2000	0	74	74	0	0	0	0	74	74	0	0	0	0	0	0
11 2001	872	91	963	872	17	889	0	74	74	0	0	0	0	0	0
12 2002	287	74	361	287	0	287	0	74	74	0	0	0	0	0	0
13 2003	113	74	187	113	1	113	0	74	74	0	0	0	0	0	0
14 2004	0	74	74	0	0	0	0	74	74	0	0	0	0	0	0
15 2005	0	74	74	0	0	0	0	74	74	0	0	0	0	0	0
16 2006	550	77	627	550	3	553	0	74	74	0	0	0	0	0	0
17 2007	113	74	187	113	1	114	0	74	74	0	0	0	0	0	0
18 2008	0	74	74	0	0	0	0	74	74	0	0	0	0	0	0
19 2009	0	74	74	0	0	0	0	74	74	0	0	0	0	0	0
20 2010	0	74	74	0	0	0	0	74	74	0	0	0	0	0	0
21 2011	1,428	170	1,597	1,428	96	1,524	0	74	74	0	0	0	443	78	521
22 2012	1,159	229	1,388	1,159	156	1,314	0	74	74	0	0	0	872	156	1,028
23 2013	1,333	340	1,673	1,333	266	1,599	0	74	74	0	0	0	1,333	266	1,599
24 2014	371	372	743	371	298	669	0	74	74	0	0	0	371	298	669
25 2015	1,645	823	2,468	1,645	749	2,394	0	74	74	0	0	0	1,532	749	2,281
Salvage cost	-4,477	-1,647	-6,124	-4,477	-1,647	-6,124	0	0	0	-107	-251	-357	-3,953	-1,389	-5,342
TOTAL	10,532	3,880	14,412	10,532	2,037	12,569	0	1,843	1,843	118	277	395	5,151	1,705	6,855

	MACHINERYinstall			MACHINERY MOBILE			MOTOR VEHICLE			EQUIPMENT,TOOL			LABOUR			O & M LABOUR			O & M		
	F.C.	L.C.	TOTAL	F.C.	L.C.	TOTAL	F.C.	L.C.	TOTAL	F.C.	L.C.	TOTAL	F.C.	L.C.	TOTAL	F.C.	L.C.	TOTAL	F.C.	L.C.	TOTAL
1 1991	322	14	336	296	3	299	254	0	254	113	1	113	158	0	158	0	48	48	0	26	26
2 1992	286	0	286	0	0	0	1	0	1	0	0	0	79	0	79	0	48	48	0	26	26
3 1993	0	0	0	0	0	0	0	0	0	0	0	0	79	0	79	0	48	48	0	26	26
4 1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	48	0	26	26
5 1995	0	0	0	0	0	0	0	0	0	113	1	113	0	0	0	0	48	48	0	26	26
6 1996	0	0	0	296	3	299	254	0	254	0	0	0	0	0	0	0	48	48	0	26	26
7 1997	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	48	48	0	26	26
8 1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	48	0	26	26
9 1999	0	0	0	0	0	0	0	0	0	113	1	113	0	0	0	0	48	48	0	26	26
10 2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	48	0	26	26
11 2001	322	14	336	296	3	299	254	0	254	0	0	0	0	0	0	0	48	48	0	26	26
12 2002	286	0	286	0	0	0	1	0	1	0	0	0	0	0	0	0	48	48	0	26	26
13 2003	0	0	0	0	0	0	0	0	0	113	1	113	0	0	0	0	48	48	0	26	26
14 2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	48	0	26	26
15 2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	48	0	26	26
16 2006	0	0	0	296	3	299	254	0	254	0	0	0	0	0	0	0	48	48	0	26	26
17 2007	0	0	0	0	0	0	1	0	1	113	1	113	0	0	0	0	48	48	0	26	26
18 2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	48	0	26	26
19 2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	48	0	26	26
20 2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	48	0	26	26
21 2011	322	14	336	296	3	299	254	0	254	113	1	113	0	0	0	0	48	48	0	26	26
22 2012	286	0	286	0	0	0	1	0	1	0	0	0	0	0	0	0	48	48	0	26	26
23 2013	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	48	0	26	26
24 2014	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	48	48	0	26	26
25 2015	0	0	0	0	0	0	0	0	0	113	1	113	0	0	0	0	48	48	0	26	26
Salvage cost	-333	-7	-340	0	0	0	0	0	0	-84	0	-85	0	0	0	0	0	0	0	0	0
TOTAL	1,491	35	1,526	1,479	17	1,497	1,274	0	1,274	703	4	707	315	0	315	0	1,205	1,205	0	638	638

(3) WATER TARIFF AND REVENUE

Incremental revenue resulting from the proposed improvement projects are:

1) to increase water consumption and to increase revenue from legal customers by (facility) rehabilitation programmes
2) to increase water billings by meter installation at "high" domestic customers
3) to decrease illegal connections, thereby increasing income
4) to increase the amount of cash being collected.

By implementing the Project, water consumption will increase. However, revenue cannot increase if NUWA bills customers using the presently assessed charges. Presently, users can consume more water without extra water charges.

It is required that the average water consumption, which is used in order to bill unmetered consumers at present, must be reassessed. The rank of zones must be raised, according to the increase in the volume of water consumption. The suppression factor will increase - from 0.87 in 1990 to 1.00 in 1995. In 1995, water consumption is expected to increase 15% over its 1990 level.

The incremental revenue resulting from the rehabilitation projects is estimated in Table 5.25, before considering the effects of the administrative improvement projects. In 1995, the increased revenue from rehabilitation projects is expected to be T.Shs. 455 million. However, 30% of the revenue is assumed to remain uncollected without administrative improvement.

TABLE 5.25 ESTIMATED REVENUE OF "FACILITY" REHABILITATION PROJECTS (1991 - 1995)

(Unit: T.Shs. million)

	1991	1992	1993	19941995
LEAKAGE CONTROL				
INCREASED BILLINGS	54	162	271	381455
INCREASED REVENUE COLLECTED	38	113	190	267319
METER INSTALLATION				
INCREASED REVENUE COLLECTED (1)	27	109	96	109109
TOTAL INCREASED REVENUE COLLECTED	65	195	299	376428

(1) refer to 6.4.2 in Chapter 6

As it is difficult to define the effect of administrative improvement programmes (reduction of illegal connection and arrears), the financial viability of the Project including the effects of administrative improvement has been examined, according to the improvement level.

The effects of administrative programmes have been assumed for 11 cases in Table 5.26, according to the improvement level of reduction in illegal connections and arrears by 10%. The basis has been assumed as reduced by 50%.

TABLE 5.26 IMPROVEMENT LEVEL IN REDUCTION OF ILLEGAL CONNECTION & ARREARS

(1) Reduction in illegal connection & bad debts	(2) Number of illegal connections in 1995	(3) Per cent of arrears of total billings in 1995
0 %	63,000	30 %
10 %	56,700	27 %
20 %	50,400	24 %
30 %	44,100	21 %
40 %	37,800	18 %
50 % (Basic Case)	31,500	15 %
60 %	25,200	12 %
70 %	18,900	9 %
80 %	12,600	6 %
90 %	6,300	3 %
100 %	0	0 %

Table 5.27 shows the financial benefit of the Project by adopting this basic case to estimate the revenue resulting from the proposed project. The incremental revenue per illegal connection reduced is estimated at T.Shs. 641 per month (multiplying T.Shs. 381.6 by 1.68), adopting Rank 9 of the domestic assessed charge.

TABLE 5.27 INCREASED REVENUE COLLECTION FROM THE PROJECT (50 % REDUCTION, 1991 - 1995)

(Unit: T.Shs.million)

	1991	1992	1993	1994	1995
Increased Revenue by:					
1)Leakage Control	38	113	190	267	319 (33%)
2)Meter Installation	27	82	109	109	109 (11%)
3)Illegal Reduction	19	60	104	150	195 (20%)
(Number of Illegal connection)	(59,500)	(52,500)	(45,500)	(38,500)	(31,500)
4)Arrears Reduction					
(% of Arrears)	(28%)	(25%)	(22%)	(18%)	(15%)
In current Billings	29	86	140	193	244 (25%)
In increased Billings by Project	1	12	35	69	110 (11%)
Total Increased Revenue collected	115	354	578	788	977(100%)

Incremental revenue from leakage control, meter installation, reduction of illegal connections and arrears in the basic case is estimated at 319, 109, 195 and 354 T.Shs. million, or 33%, 11%, 20% and 36% of the total incremental revenue, respectively, in 1995. Incremental revenue of the 10 other cases are presented in section 6, Appendix D.

(4) FINANCIAL ANALYSIS

The schedule of costs and benefits during the project life are given in Table 5.28 and the financial internal rate of return (FIRR) is calculated. Table 5.29 shows a summary of the calculated results of the FIRR and the net present value (NPV) at discount rates of 3% and 10%.

As shown in Table 5.29, the NPV of costs exceed benefits discounted at 3% in four cases, where the improvement is estimated to be 0%, 10%, 20% and 30%, respectively. If reduction of illegal and bad debts cannot be expected at 40% or more, the Project cannot be acceptable from a financial point of view. When they are 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 basis case is 7.2 %. However, it is expected that there is room for improvement greater than 50%. Accordingly, it is desirable to reduce it to 70% by raising the efficiency of administrative improvement programmes, 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 efficiency of administrative improvement programmes. The required reduction of illegal connections and arrears is 40% or more at the lowest.

TABLE 5.29 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%

TABLE 5.28 COSTS AND BENEFIT OF THE PROPOSED PROJECT(1/2)

T.Shs. million

		IMPROVEMENT 100%			IMPROVEMENT 90%			IMPROVEMENT 80%			IMPROVEMENT 70%			IMPROVEMENT 60%			IMPROVEMENT 50%		
		REVENUE COLLECTED	COST	PROFIT	REVENUE COLLECTED	COST	PROFIT	REVENUE COLLECTED	COST	PROFIT	REVENUE COLLECTED	COST	PROFIT	REVENUE COLLECTED	COST	PROFIT	REVENUE COLLECTED	COST	PROFIT
1	1991	165	1,755	-1,590	155	1,755	-1,600	145	1,755	-1,610	135	1,755	-1,620	125	1,755	-1,630	115	1,755	-1,640
2	1992	520	1,467	-947	486	1,467	-981	453	1,467	-1,014	419	1,467	-1,048	386	1,467	-1,081	354	1,467	-1,113
3	1993	881	1,752	-871	818	1,752	-934	757	1,752	-995	696	1,752	-1,056	636	1,752	-1,116	578	1,752	-1,174
4	1994	1,250	743	507	1,154	743	411	1,059	743	316	967	743	224	876	743	133	788	743	45
5	1995	1,610	3,220	-1,610	1,476	3,220	-1,744	1,346	3,220	-1,874	1,220	3,220	-2,000	1,097	3,220	-2,123	977	3,220	-2,243
6	1996	1,610	627	983	1,476	627	849	1,346	627	719	1,220	627	593	1,097	627	470	977	627	350
7	1997	1,610	74	1,536	1,476	74	1,402	1,346	74	1,272	1,220	74	1,146	1,097	74	1,023	977	74	903
8	1998	1,610	74	1,536	1,476	74	1,402	1,346	74	1,272	1,220	74	1,146	1,097	74	1,023	977	74	903
9	1999	1,610	187	1,423	1,476	187	1,289	1,346	187	1,159	1,220	187	1,033	1,097	187	910	977	187	790
10	2000	1,610	74	1,536	1,476	74	1,402	1,346	74	1,272	1,220	74	1,146	1,097	74	1,023	977	74	903
11	2001	1,610	963	647	1,476	963	513	1,346	963	383	1,220	963	257	1,097	963	134	977	963	14
12	2002	1,610	361	1,249	1,476	361	1,115	1,346	361	985	1,220	361	859	1,097	361	736	977	361	616
13	2003	1,610	187	1,423	1,476	187	1,289	1,346	187	1,159	1,220	187	1,033	1,097	187	910	977	187	790
14	2004	1,610	74	1,536	1,476	74	1,402	1,346	74	1,272	1,220	74	1,146	1,097	74	1,023	977	74	903
15	2005	1,610	74	1,536	1,476	74	1,402	1,346	74	1,272	1,220	74	1,146	1,097	74	1,023	977	74	903
16	2006	1,610	627	983	1,476	627	849	1,346	627	719	1,220	627	593	1,097	627	470	977	627	350
17	2007	1,610	187	1,423	1,476	187	1,289	1,346	187	1,159	1,220	187	1,033	1,097	187	910	977	187	790
18	2008	1,610	74	1,536	1,476	74	1,402	1,346	74	1,272	1,220	74	1,146	1,097	74	1,023	977	74	903
19	2009	1,610	74	1,536	1,476	74	1,402	1,346	74	1,272	1,220	74	1,146	1,097	74	1,023	977	74	903
20	2010	1,610	74	1,536	1,476	74	1,402	1,346	74	1,272	1,220	74	1,146	1,097	74	1,023	977	74	903
21	2011	1,610	1,597	13	1,476	1,597	-121	1,346	1,597	-251	1,220	1,597	-377	1,097	1,597	-500	977	1,597	-620
22	2012	1,610	1,388	222	1,476	1,388	88	1,346	1,388	-42	1,220	1,388	-168	1,097	1,388	-291	977	1,388	-411
23	2013	1,610	1,673	-63	1,476	1,673	-197	1,346	1,673	-327	1,220	1,673	-453	1,097	1,673	-576	977	1,673	-696
24	2014	1,610	743	867	1,476	743	733	1,346	743	603	1,220	743	477	1,097	743	354	977	743	234
25	2015	1,610	-3,656	5,266	1,476	-3,656	5,132	1,346	-3,656	5,002	1,220	-3,656	4,876	1,097	-3,656	4,753	977	-3,656	4,633
TOTAL		36,626	14,412	22,214	33,609	14,412	19,197	30,680	14,412	16,268	27,837	14,412	13,425	25,060	14,412	10,648	22,352	14,412	7,940
NPV(3%)		25,356	12,177	13,180	23,276	12,177	11,099	21,255	12,177	9,079	19,293	12,177	7,117	17,376	12,177	5,199	15,507	12,177	3,330
NPV(10%)		12,767	9,053	3,714	11,731	9,053	2,678	10,724	9,053	1,671	9,745	9,053	692	8,788	9,053	-265	7,855	9,053	-1,198
B/C(3%)				2.08			1.91			1.75			1.58			1.43			1.27
B/C(10%)				1.41			1.30			1.18			1.08			0.97			0.87
FIRR				18.2%			16.0%			13.8%			11.6%			9.4%			7.2%

TABLE 5.28 COSTS AND BENEFIT OF THE PROPOSED PROJECT(2/2)

T.Shs. million

		IMPROVEMENT 40%			IMPROVEMENT 30%			IMPROVEMENT 20%			IMPROVEMENT 10%			IMPROVEMENT 0%		
		REVENUE COLLECTED	COST	PROFIT	REVENUE COLLECTED	COST	PROFIT	REVENUE COLLECTED	COST	PROFIT	REVENUE COLLECTED	COST	PROFIT	REVENUE COLLECTED	COST	PROFIT
1	1991	105	1,755	-1,650	95	1,755	-1,660	85	1,755	-1,670	75	1,755	-1,680	65	1,755	-1,690
2	1992	321	1,467	-1,146	289	1,467	-1,178	258	1,467	-1,209	226	1,467	-1,241	195	1,467	-1,272
3	1993	520	1,752	-1,232	463	1,752	-1,289	407	1,752	-1,345	352	1,752	-1,400	299	1,752	-1,453
4	1994	702	743	-41	617	743	-126	535	743	-208	454	743	-289	376	743	-367
5	1995	860	3,220	-2,360	747	3,220	-2,473	637	3,220	-2,583	531	3,220	-2,689	428	3,220	-2,792
6	1996	860	627	233	747	627	120	637	627	10	531	627	-96	428	627	-199
7	1997	860	74	786	747	74	673	637	74	563	531	74	457	428	74	354
8	1998	860	74	786	747	74	673	637	74	563	531	74	457	428	74	354
9	1999	860	187	673	747	187	560	637	187	450	531	187	344	428	187	241
10	2000	860	74	786	747	74	673	637	74	563	531	74	457	428	74	354
11	2001	860	963	-103	747	963	-216	637	963	-326	531	963	-432	428	963	-535
12	2002	860	361	499	747	361	386	637	361	276	531	361	170	428	361	67
13	2003	860	187	673	747	187	560	637	187	450	531	187	344	428	187	241
14	2004	860	74	786	747	74	673	637	74	563	531	74	457	428	74	354
15	2005	860	74	786	747	74	673	637	74	563	531	74	457	428	74	354
16	2006	860	627	233	747	627	120	637	627	10	531	627	-96	428	627	-199
17	2007	860	187	673	747	187	560	637	187	450	531	187	344	428	187	241
18	2008	860	74	786	747	74	673	637	74	563	531	74	457	428	74	354
19	2009	860	74	786	747	74	673	637	74	563	531	74	457	428	74	354
20	2010	860	74	786	747	74	673	637	74	563	531	74	457	428	74	354
21	2011	860	1,597	-737	747	1,597	-850	637	1,597	-960	531	1,597	-1,066	428	1,597	-1,169
22	2012	860	1,388	-528	747	1,388	-641	637	1,388	-751	531	1,388	-857	428	1,388	-960
23	2013	860	1,673	-813	747	1,673	-926	637	1,673	-1,036	531	1,673	-1,142	428	1,673	-1,245
24	2014	860	743	117	747	743	4	637	743	-106	531	743	-212	428	743	-315
25	2015	860	-3,656	4,516	747	-3,656	4,403	637	-3,656	4,293	531	-3,656	4,187	428	-3,656	4,084
TOTAL		19,708	14,412	5,296	17,151	14,412	2,739	14,662	14,412	250	12,258	14,412	-2,154	9,923	14,412	-4,489
NPV(3%)		13,681	12,177	1,504	11,915	12,177	-262	10,195	12,177	-1,982	8,532	12,177	-3,644	6,918	12,177	-5,259
NPV(10%)		6,942	9,053	-2,111	6,058	9,053	-2,995	5,197	9,053	-3,856	4,363	9,053	-4,690	3,553	9,053	-5,500
B/C(3%)				1.12			0.98			0.84			0.70			0.57
B/C(10%)				0.77			0.67			0.57			0.48			0.39
FIRR				4.9%			2.6%			0.3%			-2.3%			

5.7.2 FINANCIAL PLAN

Table 5.30 provides the cost schedule during the period 1991-1995, including inflation estimated at 5% for the foreign currency portion and 30% for local currency portions.

TABLE 5.30 DISBURSEMENT SCHEDULE OF CAPITAL COSTS

Year	Foreign currency US$ million	(T.Shs.million)	Local currency T.Shs.million
1991	8.32	(1,665)	125
1992	6.82	(1,365)	263
1993	8.17	(1,635)	584
1994	2.25	(451)	852
1995	11.93	(2,385)	4,742
Total	37.50	(7,500)	6,566

The total capital costs in foreign currency portion and in local currency portion amount to US$ 37.50 million and T.Shs.6,566 million, respectively.

The financing of the project has yet to be identified, however tentative financing plans have been formulated. Other than generated project revenue, project costs will be financed by:
- Grant from government
- Soft loans at subsidized rates
- Hard loans at commercial rates

Using the most optimistic projection (100% reduction) to estimate the benefits of administrative improvement, 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 a form of soft loan or grants are required to implement the Project.

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

In order to implement the Project, being financed by soft loans, illegal connections and arrears are required to reduce 30% as the present level in 1995.

Tentative financing plans have been formulated for two cases, financed by grants and by soft loans at subsidized rate, and the cash-flow of the Project has been examined in section 6 "Financing plan", Appendix D.

5.7.3 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 in condition of water shortages when water borne diseases can pass 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 and increase the water consumption.

The consumers' willingness to pay resulting from increased water consumption has been estimated, as reflected by the charges for water consumption in 5.4.2. 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 is estimated at T.Shs. 10,589 million and T.Shs. 10,347 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 valued in the condition where 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 loss 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.

BENEFICIARY

About 70 % of people lives in an inadequately supplied areas in 1990, according to the water pressure measurement (refer to section 4.2, Appendix C) and the hydraulic analysis (refer to section 5, Appendix C). Those in 1995 will surely increase, taking into account of the increasing demand and the no-increasing supply amount. 80 % is not an unrealistic estimation, namely about 1.2 million people will suffer from water shortage, more or less. The rehabilitation project will consequently benefit the 1.2 million people.

The benefit of each component of the rehabilitation project is tabulated in Table 5.31. This is derived from the same hydraulic analysis, used in the project selection. Considering that the saved amount is 33,300 m3/day, per capita saved amount is 27 liters. In other word, 27 liters suppression will be alleviated with the project, out of the overall 100 liters demand.

TABLE 5.31 NUMBER OF BENEFICIARIES FROM EACH REHABILITATION PROJECT

(Unit: person)

MEASURE	Number of Beneficiary	Accumulated Beneficiary
1.LEAKAGE CONTROL MEASURE (Lower Ruvu Transmission System)	62,000	62,000
2.LEAKAGE CONTROL MEASURE (Distribution System)	288,000	350,000
3.MIDDLE ZONE	62,000	412,000
4.EXISTING PIPE CONNECTION	388,000	800,000
5.MAIN PIPE LAYING (PRIMARY)] 6.MAIN PIPE LAYING (SECONDARY)]	415,000	1,215,000

5.8 STAFF AND TRAINING

System changes and increase in number of staff members is envisaged, though not a drastic ones, with the introduction of the following works.

(1) Leakage Control,

(2) Pipe Cleaning,

(3) Mapping and

(4) Metering

Requirement of human resources in the above works is discussed in Chapter 6, and the total requirement except labourers is given below. Their availability is also discussed in section 7.2.6.

TABLE 5.32 PERSONNEL REQUIREMENT FOR REHABILITATION PROJECT

(Unit: Person)

	ENGINEER	TECHNICIAN	SURVEYOR/ DRAFTSMAN	DRIVER	CRANE OPERATOR
1. Leakage Control	4	74	0	14	11
2. Pipe Cleaning	2	24	0	8	8
3. Mapping	1	0	8	0	0
4. Metering	0	36	0	4	0
TOTAL	7	134	8	26	19

The necessity to train related staff members 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 projects to be carried out, repair sub-section of leakage control section, mapping section and meter installation work in metering section does not require any specific courses apart from ordinary on-the-job brushes-up. This is discussed in section 7.4.5.

CHAPTER 6

OPERATION/MAINTENANCE IMPROVEMENT PROGRAMME