```
                                   ┌─ Accountant:
                                   │    Assistant Supply Officer
            ┌─ Supplies: ──────────┤                      ┌─ Collecting: ──── Collector
            │   SrSplO             └─ Purchasing: ────────┤    AssSpplyO
            │                          SplO               └─ Pricing: ─────── Quotations
            │                                                 AssSpplyO          Handler
Chief ──────┤                                             ┌─ Register: ────── Recorder
PrSplO      │                      ┌─ StockControl: ──────┤    HiClkO
            │                      │    StoreKeeper       └─ Recoupment: ──── Storer
            └─ Stores: ────────────┤                           HiClkO
                SrStrO             │                      ┌─ Dispatching: ─── Dispatcher
                                   └─ Ware House: ────────┤    Store Man
                                       StoreKeeper        └─ Receiving: ───── Receiver
                                                               Store Man
```

FIGURE 3.4 ORGANIZATION OF STORES & SUPPLIES SECTION

```
End User      Auditor       Accounts      Supplies Section        Supplier
                                           Purchase  Collector
PRF1,3,6--------------------------------->*1   LPO1-------------->
PRF2------------------------->/            PRF3 to Record
PRF4= <-------------------------------------- +GRA1   PRF6= <----Material
                 <-----------PV1 == LPO2=GRA2=    <--------------Invoice:I
                             /<-----LPO3  Invoice to Record
     <------------------------------LPO4
                             PV2+Cheque------------------------->
PRF5 to Record               PV3 to HQ for replenishment of Imprest
                             PV4 to record
```

*1 In case the price >=T.Shs.200,000, the purchase becomes a matter for the HQ.
In case T.Shs.200,000> the price >=T.Shs50,000, a tender is carried out by five men branch tender committee to select suitable supplier.
In case the price <T.Shs50,000, SSS can buy it.

Legend: PRF=Purchase Requisition Form, LPO=Local Purchase Order, GRA=Goods Received Advice, PV=Payment Voucher.

FIGURE 3.5 PROCEDURE FOR PURCHASING MATERIALS

3.2.4 COMMUNICATION

(1) OPERATIONAL COMMUNICATIONS

The telephone network has been used to the maximum by the DSMB, and since two of the treatment plants are far away from the urban area, the DSMB office is connected to all the three treatment plants, the intake station, both the reservoirs, the sub-branch offices and the Pugu Road workshop through a radio communication network, through the new Kibaha repeater stations. Staff for emergency operations at the plants, the reservoirs and the main office are on duty, 24 hours a day.

There are 14 fixed radio stations, including one at the headquarters, and 12 mobile radio stations. The license for a new station at the Mtoni intake is being obtained. The frequency used is 151.5 MHz for transmitting and 155.6 MHz for receiving.

The data processing section has been able to reduce the delay in forwarding water bills from the earlier three months period to two months. The target is to reduce this even further, to 1 month.

Written communication between departments takes three months to reach their destinations.Correspondence between the headquarters and the DSMB is sometimes delayed for three to six months.

(2) COMPUTERIZATION

The master file of the payroll of NUWA is in the computer at the treasury.

Only the billing system has been computerized thus far. The original data is processed into punch-cards. The hardware used is ICL ME 29 with a magnetic tape input and disc storage. It is installed in the MOW presently. Due to the increase in the number of consumers (estimated to be about 60,000), the necessary field sizes of the variables ought to be expanded. NUWA received a new mini-computer and several personal computers in 1989.

A mini-computer has been installed in the data processing room at Gerezani. The personal computers are used independently for tabulating financial documents.

(3) MANAGEMENT INFORMATION SYSTEM

Apart from demand forecast, which is outside the scope of this rehabilitation project the following information is available to the BM at different intervals, at present.

a) Incidents which affect the capacity of treated water supply and stock of chemicals at the plants - Hourly and daily information about water supply conditions. Information regarding chemicals is given on a monthly basis.
b) distribution problems like breakage, pipe bursts and leakages - Daily reports are available for serious cases and monthly for minor ones.
c) quality of water - Daily
d) number of applications for water connections and applications still pending - Monthly
e) Resource availability : i) Manpower
   ii) Transport
   iii) Minimum stock of essential materials
   iv) three basic financial statements
   v) balance between budget allocations & actual expenditure

i) and ii) are available monthly; iii) information about chemicals stock only are available monthly iv) and v) half yearly

f) delay in billing and debt recovery - three months last time; hopefully two months this time

g) complaints lodged by customers - About a hundred letters reach the BM monthly. Information on complaints is available not only to the BM but also to the DG. Two main complaints are 1) customers do not receive bills and 2) paid amounts are not deducted from their bills. Settlement of accounts are made at the reconciliation section of the finance department.

(4) PUBLIC RELATIONS

NUWA broadcasts once a week in the evening appealing to the people to curtail wastage of water and to pay water bills on time.

There are complaint counters at the main Gerezani office and at all the sub-branch offices.

3.3 FINANCIAL STATUS

According to Section 27 of the Urban Water Supply Act, NUWA, as a parastatal organization, is expected to break even financially, with revenue from the sale of water covering all expenditures, including debt servicing charges and capital expenditure. NUWA is not required to make any profit from providing this service to the public.

The enterprise has been charged with the responsibility of meeting societal requirements for safe drinking water. Above all, it is responsible for ensuring continuous supply of drinking water to the residents in its service area. Further, it cannot reject any request for water supply from any resident within the service area.

3.3.1 WATER TARIFF

Since drinking water is one of the basic human needs (BHN), leniency to water bill payment defaulters clashes with the egalitarian ideals of socialism. The enterprise has tried to charge for water on the basis of a minimum charge plus a charge based on volume consumed. Due to difficulty in maintaining meters, but at the same time trying to improve its financial status, NUWA has introduced engineering-oriented classification of service-zones by pressure as a interim solution. Consequently, house owners in high pressure zones have benefitted enormously, as the difference in the rates does not reflect the difference in volume consumed.
Section 33 (1) of the urban water supply act specifies that the board may charge water rate with the consent of the Minister. The rate is to be notified in the Gazette.

In the last 5 years, two studies have been completed by consultants regarding financial systems, including the tariff structure. "Study on Costs and Tariffs, Supplementary Report", prepared by VIAK AB and financed by SIDA was submitted to the then Ministry of Water and Energy in 1985. This report served as the basis for a paper prepared by NUWA in 1986 for the introduction of a revised tariff structure. There were, however, several factors which were not accounted for in this paper.

"Study of the existing financial system" was prepared by Crown Agents in 1986 and reviewed all relevant factors and updated the requisite figures for a new tariff structure for NUWA. From the 1st of July, 1988, a new tariff structure was adopted by the Government for water consumers in the Mainland.

The earlier tariff structure has been in use from the end of the 70s, during the period when the DSM Water Supply Corporation Sole was in charge of water supply. Despite incurring losses, no changes were made to the tariff structure until 1st July 1988. Due to this, NUWA had an overall deficit until the fiscal year 1987-88.

(1) WATER TARIFF STRUCTURE

The new water tariff is structured in such a way that NUWA should, at the very least, be able to break even. In this structure, consumer classification is employed in place of the flat rate charged earlier and different water rates are applied to different consumer groups. A comparison of the new and old tariffs, as well as the rates applied to each consumer category, are shown in Table 3.6.

TABLE 3.6 TARIFF STRUCTURE IN MAINLAND TANZANIA

(Unit: T.Shs.)

	New Tariff (July 1988 --)		Old Tariff (-- June 1988)	
Water Consumption	per 1000 gallons	per m^3*	per 1000 gallons	per m^3*
Domestic Customer	57.25	(12.58)	13.50	(2.97)
Standpipe Customer	57.25	(12.58)	13.50	(2.97)
Institutional Customer	90.00	(19.78)	13.50	(2.97)
Commercial Customer	192.00	(42.20)	13.50	(2.97)
Industrial Customer	248.40	(54.59)	13.50	(2.97)
Reconnection Fee (per connection)	600.00			

* reference figure only

The procedure to obtain a new water connection is to fill in an application form for a water connection at the NUWA office, paying the necessary charge estimated by NUWA for connection to the nearest water main. The new customer is given a customer and zone number.

Although monthly meter readings are to be used to calculate water charges, the DSMB of NUWA has only 669 metered connections in December 1989 (see Table 3.8), which is only 1 % of the total number of connections. Hence, the average monthly consumption for each zone is measured by such test meters and this is used to levy water charges.

In unmetered areas, the water charges are estimated in the following manner:

a) Domestic consumers, standpipes and kiosks : The served area is divided into 294 zones. These zones are further classified into fifteen ranks, according to the available water pressure. The average water consumption in each rank is used to estimate the water charge for each zone. The average consumption and the minimum water charge, classified by the rank, is given in Table 3.7. Consumers in zones where water flow is intermittent are levied a minimum charge of T.Shs. 200 per month.

b) Commercial, industrial and institutional consumers : The water charge is based on the average water consumption observed when the installed water meters were operational, or wherever necessary, by estimating the average consumption over a period of time by installing test water meters.

TABLE 3.7 AVERAGE CONSUMPTION AND MINIMUM CHARGE BY RANK

Rank	Average Consumption Gallons (m^3)*	Minimum Charge
1	3,493 (15.89)	T.Shs 200.00
2	4,166 (18.96)	238.50
3	4,358 (19.83)	249.50
4	4,600 (20.93)	263.35
5	4,966 (22.60)	284.30
6	5,133 (23.36)	294.00
7	6,075 (27.64)	347.80
8	6,150 (27.98)	352.10
9	6,666 (30.33)	381.60
10	6,750 (30.71)	386.40
11	6,987 (31.79)	400.00
12	7,625 (34.69)	436.50
13	7,860 (35.76)	450.00
14	9,500 (43.23)	543.90
15	11,354 (51.66)	650.00

* reference only

(2) WATER CONNECTIONS

NUWA has a list of connections in DSM, arranged by wards. This list has been updated in 1989 and 1990. The number of connections registered with NUWA is 59,020, as of December, 1989, and distributed according to customer groups, as follows:

TABLE 3.8 NUMBER OF REGISTERED CONNECTIONS (DECEMBER 1989)

	NUMBER OF CONNECTIONS	
CONSUMER GROUP		
Domestic	54,513	
Standpipe	7	
Institutional	1,212	
Commercial	2,786	
Industrial	502	
TOTAL	59,020	
SUB-BRANCH		METERED
Ilala	18,090	(229)
Temeke	11,105	(115)
Kinondoni	9,492	(123)
Magomeni	15,047	132)
Kawe	2,286	(70)
TOTAL	59,020	(669)

But a lot of connections have remained unregistered with NUWA. NUWA has commissioned the Ardhi Institute to undertake a house-to-house survey to, among other things, asses the magnitude of illegal connections and their locations. The result of this study is due to be submitted later in 1991.

The Preliminary census released in 1988 gives the number of households in DSM on a ward-to-ward basis. The survey conducted in each ward by the members of the Study Team to determine the proportion of households having house, yard and no water connections was described earlier.

The number of households per yard connection in the three model areas of Kariakoo, Magomeni and Kinondoni has been determined to be 3.6 households/yard connection*. This was obtained from the survey in Kariakoo, Magomeni and Kinondoni model areas. Based on this, the estimated number of households and population in each water connection category from this study is given in Table 3.9 along with the number of connections registered with NUWA in 1990 to enable comparison.

The minimum monthly charges for domestic consumers in the 294 zones are shown in Table B.3.3, Appendix B while the number of connections by zones and consumer group are given in Table B.3,4, Appendix B. The number of zone by rank is illustrated in Figure 3.6. 95 zones out of 294 belong to the rank 9.

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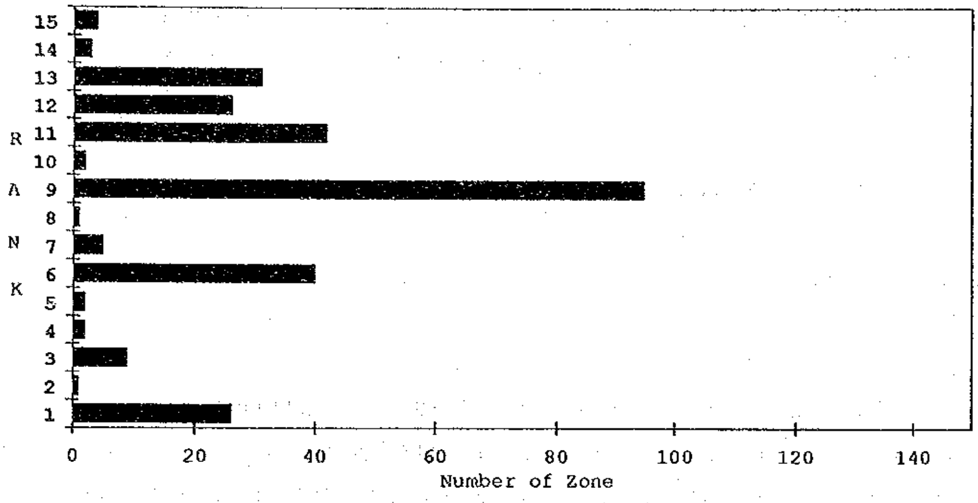
* refer to Table A.2.13, section A.2 "per capita consumption", Appendix A.

TABLE 3.9 COMPARISON OF DOMESTIC WATER CONNECTIONS BETWEEN CURRENT STUDY AND NUWA RECORDS

Sr. No. Ward	(A) Estimation by Study Team House	@Yard	Total	(B) 1990 * NUWA record	Ratio B/A
ILALA Sub-branch					
101 Ukonga	1,112	618	1,730	236	14%
102 Pugu					
104 Tabata	623	173	796	568	71%
105 Kinyerezi	90	4	94	94	100%
106 Ilala	5,431	754	6,185	2,312	37%
107 Mchikichini	1,481	411	1,892	82	4%
108 Vingunguti	959	266	1 225		
109 Kipawa (1)	1,019	283	1,302	567	22%
110 Buguruni	5,798	1,208	7,006	213	3%
111 Kariakoo	1,647	153	1,800	1,607	89%
112 Jangwani	479	311	790	757	96%
113 Gerezani	1,454	71	1,525	744	
114 Kisutu (2)	1,866	0	1,866	3,483	82%
115 Mchafukoge	1,762	0	1,762		
116 Upanga East(3)	826	0	826	2,045	248%
117 Upanga West	1,794	0	1,794	1,534	86%
118 Kivukoni	858	0	858	444	52%
SUB-TOTAL	27,199	4,252	31,451	14,686	47%
TEMEKE Sub-branch					
201 Kigamboni (4)	619	516	1,135	139	12%
202 Vijibweni	26	22	48		
207 Mbagala	524	582	1,106	872	79%
209 Yombo-Vituka	115	128	243		
212 Miburani	3,689	1,025	4,714		
213 Temeke 14	7,338	2,038	9,376	5,364	57%
214 Mtoni	1,605	743	2,348	1,862	79%
215 Keko	4,034	320	4,354	1,253	29%
216 Kurasini (5)	2,540	176	2,716	1,087	15%
SUB-TOTAL	20,490	5,551	26,041	10,577	41%
KINONDONI Sub-branch					
301 Msasani	11,905	0	11,905	2,920	25%
302 Kinondoni	4,185	872	5,057	3,420	68%
303 Mwananyamala	4,652	2,326	6,978	2,632	38%
SUB-TOTAL	20,742	3,198	23,940	8,972	38%
KAWE Sub-branch					
402 Kawe	4,058	501	4,559	4,216	93%
SUB-TOTAL	4,058	501	4,559	4,216	93%
MAGOMENI Sub-branch					
501 Magomeni (6)	958	399	1,357	2,290	30%
502 Makurumla	3,566	991	4,557	385	8%
503 Ndugumbi	2,614	726	3,340	921	28%
504 Tandale	1,470	1,225	2,695		
505 Mzimuni	1,276	709	1,985		
506 Kigogo	1,289	501	1,790	1,680	94%
507 Mabibo	3,546	985	4,531	1,197	26%
508 Manzese	705	979	1 684		
509 Ubungo	6,797	581	7,378	7,345	100%
SUB-TOTAL	22,221	7,095	29,316	13,818	47%
DAR ES SALAAM	94,710	20,598	115,308	52,269	45%

Notes : * as of July, 1990
@ Yard connections = No. of households having yard connections (refer to Table A.1.3, Appendix A) divided by 3.6 families per yard connection
(1) NUWA's Kipawa includes Vingunguti
(2) NUWA's Gerezani & Kisutu also includes Mchafukoge
(3) No. of NUWA connections in Upanga East exceed total number of households
(4) NUWA's Kigamboni includes Vijibweni
(5) NUWA's Kurasini includes Miburani
(6) NUWA's Magomeni includes Tandale, Mzimuni and Manzese

FIGURE 3.6 NUMBER OF ZONE BY RANK



Schools, hospitals, government offices, gardens and kiosks are included in institutional customers. Table 3.10 shows the number of connections and the total billings of DSM City Council between January and December 1989. The charges for these institutional connections are expected to be paid by the City Council. However, they are yet to be paid.

TABLE 3.10 BILLINGS TO THE DSM CITY COUNCIL (JANUARY - DECEMBER 1989)

(Unit:T.shs.thousand)

	Number of Connections	Billings
Primary School (Temeke)	20	3,202
Primary School (Kinondoni)	34	7,356
Primary School (Ilala)	27	4,615
City Council Office	35	2,465
Hospital	10	362
Garden	9	619
Kiosk	266	5,556
Total	401	24,175

Outside DSM, water connections are registered by two District Councils - Bagamayo District, which lies along the transmission pipe from the Lower Ruvu Treatment plant to DSM and Kibaha District, which lies along the transmission pipes from the Upper Ruvu Treatment Plant - both the districts have been paying water charges regularly up to July 1989. However, since July 1989, the two districts have not paid any water charges. NUWA has suggested that the two districts be incorporated into the jurisdiction of the DSM Branch Office and water charges from consumers in these areas be directly payable to NUWA.

(3) WATER CONSUMPTION BY CUSTOMER GROUP

The total billed water consumption[1] and billings by customer group is shown in Tables 3.11 and 3.12, respectively[2].

Domestic consumption accounts for 59 % of the total consumption, although domestic billings account for only 31 % of the total billings. Industrial consumers, who consume 18 % of the water pay 41 % of the total billings. This is because the volumetric charge (per 1000 gallons) used for industrial consumers is 4.3 times as expensive as that for domestic consumers.

The amount of water consumption supplied is about 30 mgd (136,500 m^3/day), while the total water consumption, from water billing records amounts to 870 million gallons per month, or 29 mgd (132,000 m^3/day). Although there are lots of illegal connections and kiosk connections that use water free of charge, the cost of this water supply is covered by legal customers, as has been intended, since the amount of water supplied and the amount of water consumed, according to billings, are almost the same.

TABLE 3.11 TOTAL BILLED CONSUMPTION CLASSIFIED BY CUSTOMER GROUPS (JULY 1989 - SEPTEMBER 1989)

(unit: million gallons per month)

Customer Group	July 1989	August 1989	September 1989	Average
Domestic	499	519	530	516 (59%)
Institutional	116	115	115	115 (13%)
Commercial	84	85	86	85 (10%)
Industrial	156	151	155	154 (18%)
Total	855	870	886	870 (100%)

---

1. Billed water consumption which is dealt in this Chapter is significantly different from used water consumption. The used consumption is explained in "Water Demand Estimate".

2. Zone-wise total billings for December, 1990 are shown in Table B.3.5, Appendix B.

TABLE 3.12 TOTAL BILLINGS CLASSIFIED BY CUSTOMER GROUPS

(JULY 1989 - SEPTEMBER 1989)

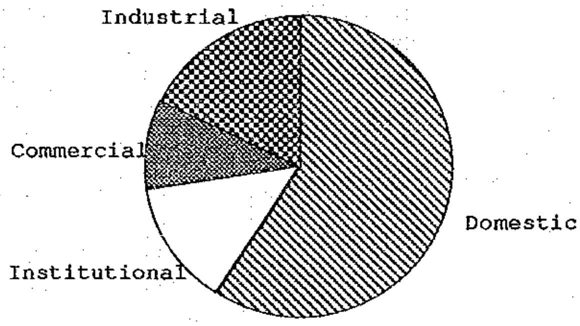
(unit: T.Shs. million per month)

Customer Group	July 1989	August 1989	September 1989	Average
Domestic	28,558	29,717	30,341	29,539 (31%)
Institutional	10,426	10,329	10,318	10,358 (11%)
Commercial	16,140	16,297	16,596	16,344 (17%)
Industrial	38,758	37,600	38,538	38,299 (41%)
Total	93,881	93,944	95,792	94,539 (100%)

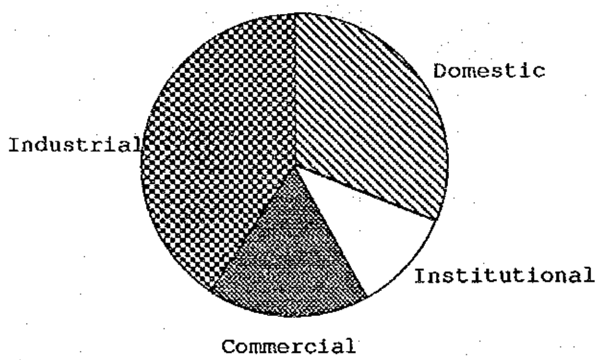
Source:NUWA

FIGURE 3.7 TOTAL WATER CONSUMPTION AND TOTAL BILLINGS CLASSIFIED BY CUSTOMERS GROUP (JULY - SEPTEMBER 1989)

WATER CONSUMPTION



WATER BILLINGS



The number of water connections classified by wards and by customer groups are shown in Table 3.13. In Temeke ward, there are 285 industrial connections, or 61 % of the total industrial connections. Commercial consumers are concentrated in Kisutu ward.

TABLE 3.13 NUMBER OF REGISTERED WATER CONNECTIONS BY WARDS AND CUSTOMER GROUPS (DECEMBER 1989)

Sub-branch	Ward	Domestic Customer	Standpipe Customer	Commercial Customer	Industrial Customer	Institution Customer	Total
Ilala	Ukonga	480	0	9	2	15	506
	Tabata	511		36	2	2	551
	Kinyerezi	92		1			93
	Ilala	2,531	0	158	5	37	2,731
	Mchikichini	82					82
	Kipawa	1,205	0	63	36	58	1,362
	Buguruni	986	0	56	4	8	1,054
	Kariakoo	1,578	0	128	4	9	1,719
	Jangwani	735	0	53	2	2	792
	Gerezani	742	0	65	7	10	824
	Kisutu	3,385	0	505	12	69	3,971
	Upanga East	2,036	0	4	0	55	2,095
	Upanga West	1,531	0	4	0	120	1,655
	Kivukoni	442	0	47	3	163	655
Sub-total		16,336	0	1,129	77	548	18,090
Temeke	Kigamboni	134		3	4	9	150
	Mbagala	747	1	6	1		755
	Temeke	5,197	1	192	285	153	5,828
	Mtoni	1,782	0	47	0	7	1,836
	Keko	1,194	1	79	29	65	1,368
	Kurasini	1,057	0	49	12	50	1,168
Sub-total		10,111	3	376	331	284	11,105
Kinondoni	Msasani	2,782	0	134	3	64	2,983
	Kinondoni	3,422	1	287	3	57	3,770
	Mwananyamala	2,498	0	222	1	18	2,739
Sub-total		8,702	1	643	7	139	9,492
Kawe	Goba	607		9	8	10	634
	Kawe	3,929	0	128	54	180	4,291
	Bunju	346	2	8	4	1	361
Sub-total		4,882	2	145	66	191	5,286
Magomeni	Magomeni	2,217	0	140	0	0	2,357
	Makurumla	468	1	7	0	0	476
	Ndugumbi	793	0	41	0	2	836
	Kigogo	1,601	0	25	2	1	1,629
	Mabibo	1,081	0	10	0	0	1,091
	Ubungo	6,895	0	263	19	38	7,215
	Kibamba	1,427	0	7	0	9	1,443
Sub-total		14,482	1	493	21	50	15,047
Total		54,513	7	2,786	502	1,212	59,020

Note: Number of connections classified by zones are shown in Table B.3.4, Appendix B.

3.3.2 ACCOUNTING SYSTEM OF NUWA DAR ES SALAAM

(1) ACCOUNTING SYSTEM

The fiscal year in Tanzania starts from the first of July of a calendar year and ends with the 30th of June of the next calendar year.

Section 38 (1) of Urban Water Supply Act states that the board of NUWA shall keep proper account books and records.

The objectives of accounting system are;
a. to record the assets, liabilities, income and expenditures of NUWA.
b. to provide information to HQ, and for HQ to all levels of management to enable effective control to be maintained, and
c. to provide a suitable framework for financial planning and, in particular, for annual budgeting and reporting.

The guidelines for the system are provided by NUWA's Accounts Operating Manuals (AOMs). There is one for the HQ and another for branch offices. The basic documents to be maintained and the forms to be used are specified in it. Monthly totals in books at the branches are transferred to the HQ for compilation of a monthly management report, which is returned to all accountable levels of management for reference.

A budgetary control book is maintained to check and control actual expenses.

(2) BUDGETING

The act specifies, in Section 27, that the Board of NUWA shall pass a detailed budget for a fiscal year before its commencement. The minister's approval authorizes the Board to execute the disbursement in accordance to the budget. A supplementary budget may be passed, in case of unforeseeable developments after the beginning of the fiscal year.

The responsibilities of the concerned staff members for preparing the budget is defined in the NUWA AOM. The Director of Finance (DF) has overall responsibility for producing the Recurrent Income and Expenditure Budget of NUWA. The Capital Budget is prepared by the Director of Programme Planning & Implementation and reviewed by the Director of Finance. In the context of DSMB, it is the responsibility of the Branch Accountant to estimate the income and expenditure of the branch; but it is that of the Branch Manager to ensure the budget of the branch is prepared according to the rules set by the HQ and is delivered as per the schedule fixed by the HQ.

(3) AUDIT

NUWA is required, by law, to submit its financial statements, after being audited by the Tanzanian Audit Corporation, together with the Director's report (annual report) to its parent ministry and to the National Assembly within 7 and 8 months, respectively, of the end of a fiscal year.

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

The comments in the Auditors' Reports of each fiscal year are summarized in Table B.3.6,Appendix B. The auditors' reports indicate that the following are important points in the preparation of precise financial statements by NUWA:

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

Accounting systems and procedures, as well as the billing and collection systems and procedures were studied in detail by Crown Agents in the "Study of Existing Financial Systems of the National Urban Water Authority" in 1986.

3.3.3 FINANCIAL PERFORMANCE OF NUWA DAR ES SALAAM BRANCH

From 1984/85 through 1987/88, even the operating costs of NUWA could not be covered by the operating revenue. NUWA has not achieved the financial requirement before the new tariff system was introduced on 1st July, 1988. The new tariff system was designed to meet the condition that NUWA could operate at the break even point, including capital expenditure and in 1988/89, the revenue from water users covered operating expenditure and depreciation costs.

The financial statements of NUWA are shown in Tables 3.14 to 3.16.

TABLE 3.14 PROFIT AND LOSS STATEMENT, NUWA

(Unit: T.Shs)

From to	1/7/84 30/6/85	1/7/85 30/6/86	1/7/86 30/6/87	1/7/87 30/6/88	1/7/88 30/6/89
INCOME					
Operating Income	59,469,445	96,871,090	143,400,549	198,047,067	930,610,655
Non-operating Income	2,199,386	1,013,446	509,382	1,136,679	2,491,782
Total Income	61,668,831	97,884,536	143,909,931	199,183,746	933,102,437
EXPENSES					
Operating Expenses					
Salary & Wages	15,267,332	24,431,311	32,959,729	42,802,564	43,023,183
Chemical Expenses	13,730,787	16,448,844	53,416,294	153,729,257	159,458,312
Repair & Maintenance	8,080,668	12,339,772	7,618,793	10,235,970	41,432,643
Power Cost	58,018,131	60,418,264	143,972,184	127,681,931	118,750,171
Other Expenses	10,368,711	10,622,787	10,653,185	20,478,202	29,574,387
Total Operating Expenses	105,465,629	124,260,978	248,620,185	354,927,924	392,238,696
Administrative Expenses					
Salary & Wages	1,896,642	2,719,778	3,642,593	4,361,727	15,197,821
Provision of Doubtful Debts		0	0	0	237,075,593
Other Expenses	9,588,775	16,753,379	21,490,795	30,809,267	62,217,455
Total Administrative Expenses	11,485,417	19,473,157	25,133,388	35,170,994	314,490,869
Audit Fees	475,000	400,000	600,000	603,000	850,000
Depreciation	18,361,670	19,244,030	20,678,077	17,970,072	31,907,838
Bank Charge	157,534	192,571	865,567	937,294	2,388,265
Total Expenses	135,945,250	163,570,736	295,897,217	409,609,284	741,875,668
Profit before Taxes	-74,276,419	-65,686,200	-151,987,286	-210,425,538	191,226,769
Taxes	0	0	0	0	0
Profit after Tax	-74,276,419	-65,686,200	-151,987,286	-210,425,538	191,226,769
Prior years' Adjustment	0	0	0	0	-48,265,540
Accumulated Surplus	-70,547,982	-136,234,182	-288,221,468	-498,647,006	-355,685,777

TABLE 3.15 BALANCE SHEET, NUWA

(Unit:T.Shs.)

As at	30/6/1985	30/6/1986	30/6/1987	30/6/1988	30/6/1989
Assets					
Fixed Assets					
Land & Buildings	155,094,815	151,118,025	147,141,215	143,307,425	139,327,060
Plant & Machinery	5,806,198	4,961,926	4,117,654	4,638,686	3,785,718
Water Supply Pipes	214,433,707	203,462,605	194,591,923	183,176,161	171,745,932
Motor Vehicles	5,973,799	4,465,035	5,324,143	5,114,070	24,266,913
Other Fixed Assets	9,433,539	13,492,350	13,786,466	12,779,267	32,892,547
SUB-TOTAL	390,742,058	377,499,941	364,961,401	349,015,609	372,018,170
Capital Work in Progress	48,513	13,648,060	15,411,936	57,631,585	334,180,974
Total Fixed Assets	390,790,571	391,148,001	380,373,337	406,647,194	706,199,144
Current Assets					
Stock & Stores	77,624,601	63,492,287	132,141,998	21,999,370	355,907,399
Trade Debtors	21,447,628	47,437,621	118,660,300	182,080,676	275,911,852
Staff Debtors	1,943,788	6,121,763	10,273,318	10,724,799	11,253,497
Other Debtors	131,363	4,908,052	6,466,449	9,713,148	56,419,805
Unbanked Collections	0	4,079,120	1,285,710	2,076,634	1,938,925
Cash	15,700,583	9,556,408	35,560,819	19,484,711	73,071,680
Suspense Account	0	0	0	0	1,938,925
Total Current Assets	116,847,963	135,595,251	304,388,594	246,079,338	774,503,158
Total Assets	507,638,534	526,743,252	684,761,931	652,726,532	1,480,702,302
Equity & Liabilities					
Equity					
Capital Fund	400,129,156	400,129,156	400,129,156	400,133,573	400,133,573
Accumulated Surplus	-70,547,982	-136,234,182	-288,221,468	-498,647,006	-355,685,777
Government Development Grant	6,887,366	21,087,366	169,483,604	217,545,415	875,668,354
Net Equity	336,468,540	284,982,340	281,391,292	119,031,982	920,116,150
Long-term Liabilities	0	0	0	0	0
Current Liabilities					
Creditors & Accurables	167,708,251	229,048,732	380,447,191	514,783,026	545,613,657
Bank Account-overdrawn	0	9,213,386	15,330,872	10,256,448	3,732,667
Project Deposits	2,681,564	2,496,505	4,550,301	7,206,840	10,114,071
Salary Deductions Payable	780,179	1,002,289	3,042,275	1,448,236	1,125,757
Total Current Liabilities	171,169,994	241,760,912	403,370,639	533,694,550	560,586,152
Total Liabilities	507,638,534	526,743,252	684,761,931	652,726,532	1,480,702,302

TABLE 3.16 STATEMENT OF SOURCE AND APPLICATION OF FUNDS, NUWA

(Unit:T.Shs.)

As at	30/6/1983	30/6/1984	30/6/1985	30/6/1986	30/6/1987	30/6/1988	30/6/1989
SOURCE OF FUNDS							
Surplus for the year	2,644,669	1,083,768	-74,276,419	-65,686,200	-151,987,286	-210,425,538	191,226,769
Adjustment							
Depreciation	32,310	76,489	18,361,670	19,244,030	20,678,077	17,970,072	31,907,838
Other Adjustment							-309,698
Fund Generated from Operations	2,676,979	1,160,257	-55,914,749	-46,442,170	-131,309,209	-192,455,466	222,824,909
Sale of Fixed Assets	0	0	0	0	0	0	380,000
Capital Fund	0	0	400,129,156	0	0	4,417	0
Development Grant	0	5,895,000	992,366	14,200,000	148,396,238	48,061,811	658,122,939
Total Source of Fund	2,676,979	7,055,257	345,206,773	-32,242,170	17,087,029	-144,389,238	881,327,848
APPLICATION OF FUNDS							
Acquisition of Fixed Assets	207,369	264,880	408,740,278	6,001,913	8,139,537	2,024,280	54,980,701
Addition of Capital Work in Progress	0	0	48,513	13,599,547	1,763,876	42,219,649	276,549,389
Prior Years' adjustment	0	0	0	0	0	0	48,265,540
Total Acquisition of Funds	207,369	264,880	408,788,791	19,601,460	9,903,413	44,243,929	379,795,630
INCREASE -DECREASE OF WORKING CAPITAL	2,469,610	6,790,377	-63,582,018	-51,843,630	7,183,616	-188,633,167	501,532,218
CHANGE IN WORKING CAPITAL ITEM							
Increase in Stock and Store	45,393	21,417	77,546,791	-14,132,314	68,649,711	-110,142,628	333,908,029
Increase in Trade and Debtors	0	0	21,447,628	25,989,993	71,222,679	63,420,376	93,831,176
Increase in Staff Debtors	3,550	38,010	1,902,228	4,177,975	4,151,555	451,481	528,698
Increase in Other Debtors	5,501	12,751	113,111	4,776,689	1,558,397	3,246,699	46,706,657
Increase in Deposit	0	944,800	-944,800	0	0	0	0
Increase in Unbanked Collections	0	0	0	4,079,120	-2,793,410	790,924	-2,076,634
Increase in Suspense A/C	0	0	0	0	0	0	1,938,925
Total Increase	54,444	1,016,978	100,064,958	24,891,463	142,788,932	-42,233,148	474,836,851
Increase in Creditors and accruals	138,270	41,312	167,528,669	61,340,481	151,398,459	134,335,835	30,830,631
Increase in Project Deposit	0	0	2,681,564	-185,059	2,053,796	2,656,539	2,907,231
Increase in Salary Deduction Payable	0	0	780,179	222,110	2,039,986	-1,594,039	-322,479
Total Increase	138,270	41,312	170,990,412	61,377,532	155,492,241	135,398,335	33,415,383
MOVEMENT OF LIQUID FUNDS							
Decrease in Bank Account-overdrawn	0	0	0	-9,213,386	-6,117,486	5,074,424	6,523,781
Increase in Cash	2,553,436	5,803,711	7,343,436	-6,144,175	26,004,411	-16,076,108	53,586,969
	2,553,436	5,803,711	7,343,436	-15,357,561	19,886,925	-11,001,684	60,110,750

(1) WATER PRODUCTION COSTS

Table 3.17 shows water production costs since 1984, while Table 3.18 shows the change in the expenditure for each cost item.

TABLE 3.17 WATER PRODUCTION COSTS

(Unit:T.shs. million)

From to	1/7/84 30/6/85	(%)	1/7/85 30/6/86	(%)	1/7/86 30/6/87	(%)	1/7/87 30/6/88	(%)	1/7/88 30/6/89	(%)
EXPENSES										
Operating Expenses										
Salary & Wages	15.3	(12)	24.4	(17)	33.0	(12)	42.8	(11)	43.0	(10)
Chemical Expenses	13.7	(11)	16.4	(11)	53.4	(20)	153.7	(41)	159.5	(38)
Repair & Maintenance	8.1	(7)	12.3	(9)	7.6	(3)	10.2	(3)	41.4	(10)
Power Cost	58.0	(47)	60.4	(42)	144.0	(53)	127.7	(34)	118.8	(28)
Other Expenses	10.4	(8)	10.6	(7)	10.7	(4)	20.5	(5)	29.6	(7)
Depreciation	18.4	(15)	19.2	(13)	20.7	(8)	18.0	(5)	31.9	(8)
Total Operating Expenses	123.8	(100)	143.5	(100)	269.3	(100)	372.9	(100)	424.1	(100)
Administrative Expenses	12.1		20.1		26.6		36.7		80.7	
Provision of Doubtful Debts	0.0		0.0		0.0		0.0		237.1	
Total Expenses	135.9		163.6		295.9		409.6		741.9	
Water Production	50 mgd		50 mgd		50 mgd		50 mgd		50 mgd	
Unit water Production Cost (T.shs.)										
Operating Expenses per 1,000 gallons	6.79		7.86		14.76		20.43		23.24	
Administrative Expenses per 1,000 gallons	0.66		1.10		1.46		2.01		4.42	
Provision of Doubtful Debts	(0.56) *		(0.89) *		(1.30) *		(1.80) *		12.99 (8.44) *	

( ) *: As the provisions for doubtful debts have not been made till 30/6/1989, the provision of doubtful debts in 1988/89 financial year are divided proportionally among five years.

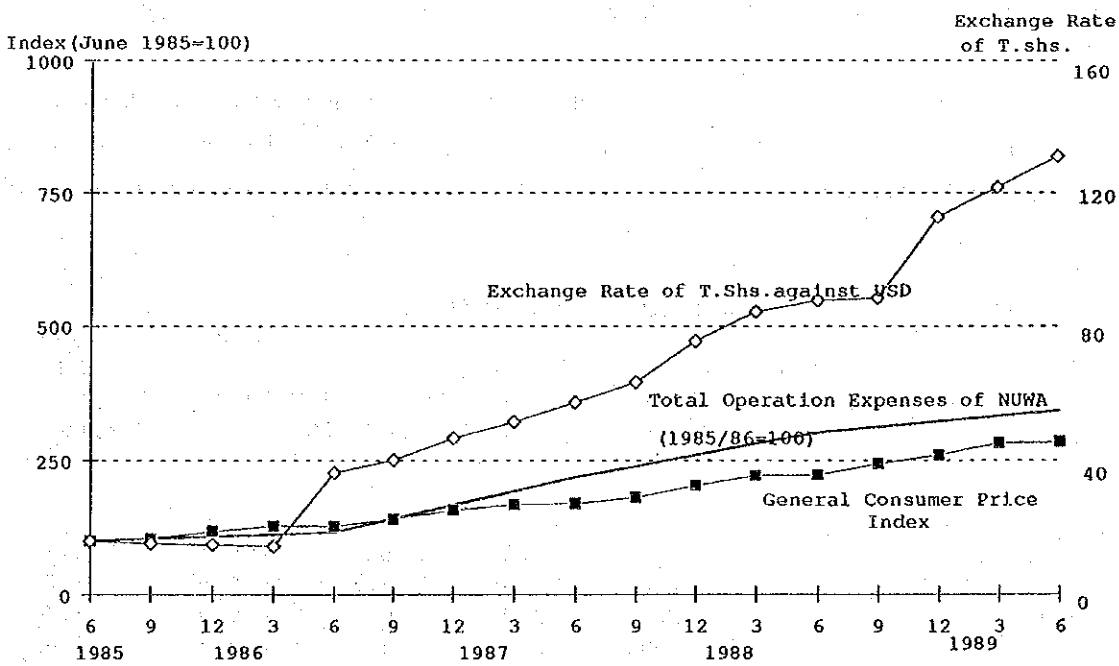
TABLE 3.18 CHANGES IN WATER PRODUCTION COSTS OF EACH COST COMPONENT OVER TIME

From to	1/7/84 30/6/85	1/7/85 30/6/86	1/7/86 30/6/87	1/7/87 30/6/88	1/7/88 30/6/89
EXPENSES					
Operating Expenses					
Salary & Wages	1.00	1.60	2.16	2.80	2.82
Chemical Expenses	1.00	1.20	3.89	11.20	11.61
Repair & Maintenance	1.00	1.53	0.94	1.27	5.13
Power Cost	1.00	1.04	2.48	2.20	2.05
Other Expenses	1.00	1.02	1.03	1.97	2.85
Depreciation	1.00	1.05	1.13	0.98	1.74
Total Operating Expenses	1.00	1.16	2.17	3.01	3.43
Administrative Expenses	1.00	1.66	2.20	3.03	6.66

Water production has been constant at 50 mgd, while operating expenditure has increased by 3.4 times between 1984-85 and 1988-89. This means that the unit production costs have increased at a rate of 36 % per annum during the last 5 years, which is greater than inflation in Tanzania, though it is lower than the rate of devaluation of Tanzanian Shillings (T.Shs) vis-a-vis the US dollar during the corresponding period. Figure 3.8 illustrates the national consumer price index, the operating expenses of NUWA and the exchange rate of T.Shs. vs the US dollar.

Unit operating cost and unit administrative expenditure per 1,000 gallons of water produced is T.Shs 23.2 (T.Shs 5.1 per m3) and T.Shs 3.4 (T.Shs 1.0 per m3), respectively in 1988-89. Assuming that half the administrative expenditure can be charged to the Head Office, the unit water production cost for the DSM branch office of NUWA per 1,000 gallons of water produced is T.Shs 25.4 (T.Shs 5.6 per m3).

FIGURE 3.8 CONSUMER PRICE INDEX, OPERATING EXPENSES OF NUWA AND FOREIGN EXCHANGE RATE (June 1985 = 100)



The percentage share of each item of expenditure has been fluctuating over the last 5 years. The following are the primary reasons for this observed fluctuation.

- rapid increase of unit expenditure cost due to devaluation of the currency
- shortage of goods and materials required, and
- improper valuation of stocks and stores

Among operating expenses, chemical and power costs are the major cost items, followed by salaries and wages.

Chemical costs amounted to 11 % of the total operating costs in 1984/85 fiscal year, while they have increased to be 36 % of the total in 1988/89 fiscal year. As shown in Table 3.3.14, chemical costs increased by 11.6 times from 1984/85 to 1988/89. All chemicals, with the exception of liquid chlorine, which is partially produced by Tanzanian Chemical Industries, are imported. NUWA purchases chemicals mainly from Government Warehouses and cannot ensure a regular supply due to constant shortage of chemicals in the country. In 1989, NUWA started receiving chemicals through import support from CIDA.

(2) REVENUE AND REVENUE COLLECTION

Income from water consumption has increased at a rate of 40 % per annum between 1985-86 and 1987-88. Income in 1988-89 was 4.9 times that of the previous year. In 1988-89, NUWA earned a profit for the first time, after 4 consecutive years of losses, due primarily to the new tariff system implemented from 1st July 1988.

TABLE 3.19 NUWA INCOME

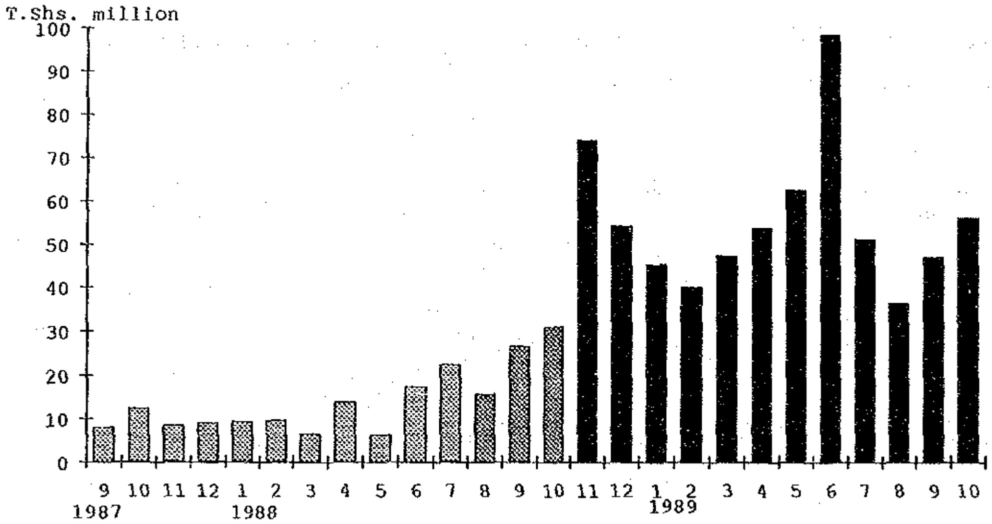
(Unit:T.Shs.million)

From To	1/7/84 30/6/85	1/7/85 30/6/86	1/7/86 30/6/87	1/7/87 30/6/88	1/7/88 30/6/89
INCOME					
Operating Income					
Water Consumption	56.3	95.1	138.3	189.7	921.7
New Connection Fee	1.2	0.9	2.3	5.5	1.0
Reconnection Fee	0.0	0.0	0.0	0.7	1.0
Maintenance Services	0.0	0.1	2.7	2.1	2.1
Sales of Materials	1.9	0.7	0.0	0.0	0.0
Surcharge	0.0	0.0	0.0	0.0	0.1
Total Operating Income	59.5	96.9	143.4	198.0	930.6
Non-operating Income	2.2	1.0	0.5	1.1	2.5
TOTAL INCOME	61.7	97.9	143.9	199.2	933.1

The actual revenue collected is that paid to NUWA by customers against billings to consumers with legal connections. Figure 3.9 indicates the actual revenue collected on a monthly basis. The revenue increased remarkably from November 1988 due to the tariff increase from July 1, 1988.

The average monthly collection under the old tariff was approximately T.Shs 10 million, and under the new tariff is T.Shs 55 million. Consequently, revenue has increased 5.5 times, which is higher than the increase rate of billings during the same period.

FIGURE 3.9 COLLECTED REVENUE (SEPTEMBER 1987 - OCTOBER 1989)



There are a large number of bills that have been sent but not paid. The total revenue receivable in 1988-89 was T.Shs 922 million, although only T.Shs. 660 million were actually collected. Actual revenue collected is estimated to be 70 % of the total theoretical revenue receivable.

(3) SOURCE OF FUNDS

The statement of source and application of funds of NUWA is given in Table 3.20. The source of funds are from operation surplus, capital and government development grants. NUWA has yet to take any long-term loans as of the 1988-89 financial year.

Accumulated surplus from operations is still showing a deficit of T.Shs. 356 million as of June end 1989 and after adjustment of depreciation the accumulated fund generated from operation has a deficit of T.Shs. 199.5 million as of the end of June, 1989, which is shown in Table 3.20.

TABLE 3.20 SOURCE OF FUNDS

(Unit:T.Shs.million)

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

Capital funds of the order of T.Shs. 400 million represent the net value of assets and liabilities taken over from DSM Water Supply Corporation Sole in October 1984.

Through government development grants, T.Shs. 876 million have been accumulated, as of June end 1989. Grants over the last three years have been allocated as follows :

1988-89 fiscal year		
Computer Hardware	T.Shs.	21,582,000
Motor Vehicles		15,688,000
TANESCO Liability		410,270,000
Upper Ruvu Rehabilitation		210,583,000
Total		658,123,000
1987-88 fiscal year		
Upper Ruvu Rehabilitation		48,062,000
Total	48,062,000	
1986-87 fiscal year		
Chemicals		113,311,000
Motor Vehicles		6,248,000
Engineering Machines		5,085,000
Water Pumps		16,420,000
Electric Motors		7,332,000
Total		148,396,000

(4) UNACCOUNTED FOR WATER

By detecting and repairing leaks, financial performance can be improved. A great deal of water loss is due to the lack of administrative programmes, such as illegal connections and the lack of an efficient billing and collecting system.

As explained in the previous chapter, leakage through distribution pipes is estimated to be 35 % of the net water supply and about 63,000 illegal connections exist among domestic consumers. Table 3.21 gives the wards where illegal customers exceed 1,000 connections.

There are not only a large number of illegal connections, but there are also quite a few legal connections that are not billed through lapses in the billing system. NUWA is currently conducting a "house to house" survey to establish records of illegal and unbilled connections. VIAK AB estimated that these losses amount to 15 % of the total production.

As previously mentioned, revenue collected is estimated to be 70 % of the total theoretical revenue.

TABLE 3.21 ESTIMATED NUMBER OF ILLEGAL CONNECTIONS BY WARD (1990)

(Unit:thousand)

Sub branch	Ward	(A) Number of registered connection NUWA record	(B) Number of house & yard connection estimated *	Number of illegal connection (B)-(A)
ILALA	Buguruni	0.2	7.0	6.8
ILALA	Ilala	2.3	6.2	3.9
ILALA	Kipawa/Vingunguti	0.6	2.5	2.0
ILALA	Mchikichini	0.1	1.9	1.8
ILALA	Ukonga	0.2	1.7	1.5
ILALA	Others	11.3	12.1	0.8
	TOTAL	14.7	31.5	16.8
TEMEKE	Kurasini/Miburani	1.1	7.4	6.3
TEMEKE	Temeke 14	5.4	9.4	4.0
TEMEKE	Keko	1.3	4.4	3.1
TEMEKE	Kigamboni/ Vijibweni	0.1	1.2	1.0
TEMEKE	Others	2.7	3.7	1.0
	TOTAL	10.6	26.0	15.5
KINONDONI	Msasani	2.9	11.9	9.0
KINONDONI	Mwananyamala	2.6	7.0	4.3
KINONDONI	Kinondoni	3.4	5.1	1.6
	TOTAL	9.0	23.9	15.0
KAWE	Kawe	4.2	4.6	0.3
	TOTAL	4.2	4.6	0.3
MAGOMENI	Magomeni (1)	2.3	7.7	5.4
MAGOMENI	Makurumla	0.4	4.6	4.2
MAGOMENI	Mabibo	1.2	4.5	3.3
MAGOMENI	Ndugumbi	0.9	3.3	2.4
MAGOMENI	Others	9.0	9.2	0.1
	TOTAL	13.8	29.3	15.5
DAR ES SALAAM		52.3	115.3	63.0

* (refer to Table 3.9)
1 NUWA's Magomeni includes Tandale, Mzimuni and Manzese.

Important data relating to water production and consumption that was collected in this study are given in Table 3.22.

TABLE 3.22 WATER PRODUCTION AND CONSUMPTION

	m³/ average day	
-Gross Supply in 1990	296,300	
-Net Supply in 1990	193,425	
(Reservoir Delivery)	(65% of gross supply)	
-Unsuppressed Consumption in 1990	144,429	(100.0%)
	(75% of net supply)	
Domestic Consumption	128,180	(88.8%)
Industrial Consumption	4,612	(3.2%)
Commercial Consumption	6,282	(4.3%)
Institutional Consumption	5,355	(3.7%)
-Suppressed Consumption in 1990	125,727	(100.0%)
	(65% of net supply)	
Domestic Consumption	111,056	(88.3%)
Industrial Consumption	4,120	(3.3%)
Commercial Consumption	5,697	(4.5%)
Institutional Consumption	4,854	(3.9%)
-Billed Consumption in 1989*	131,833	(100.0%)
	(68% of net supply)	
Domestic Consumption	78,191	(59.3%)
Industrial Consumption	23,336	(17.7%)
Commercial Consumption	12,880	(9.8%)
Institutional Consumption	17,426	(13.2%)
	T.shs./average day	
-Billing Amounts	3,151,300	(100.0%)
Domestic Consumption	984,600	(31.2%)
Industrial Consumption	1,276,600	(40.5%)
Commercial Consumption	544,800	(17.3%)
Institutional Consumption	345,300	(11.0%)
	No. of Connection	
-Registered Water Connection in December 1989	59,020	(100.0%)
Domestic Connection	54,520	(92.4%)
Industrial Connection	502	(0.9%)
Commercial Connection	2,786	(4.7%)
Institutional Connection	1,212	(2.0%)
-Illegal connection	63,000	
-Bad Debts (Billed Income not collected)	30% of the billed amount	

* : Billed consumption and amount above are calculated by using the assessed figures of NUWA from July through September 1989.

** : Consumption does not include leakage within the distribution system.

As indicated, suppressed consumption is almost equal to the billed quantity, although there are 63,000 illegal domestic connections, because billed consumptions to industrial, commercial and institutional consumers without meters are significantly overestimated.

It should be noted that although the contribution of the four groups are not proportional to demand, NUWA billings match the total quantity of water used by the four consumer groups.

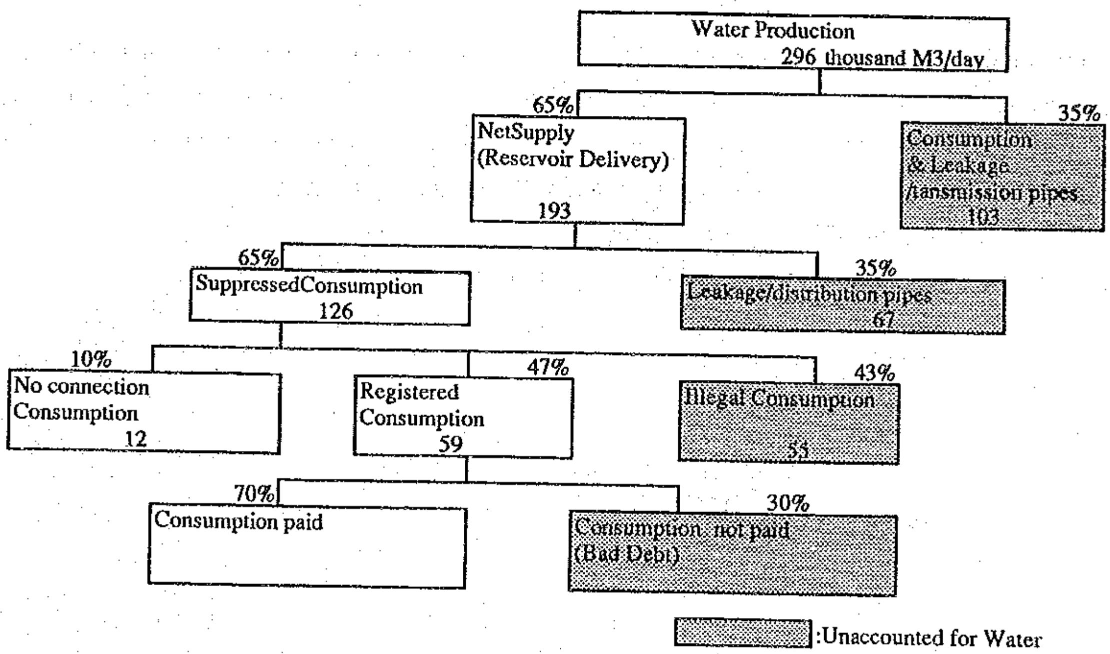
Figure 3.10 illustrated water production, consumption and losses in the DSM Water Supply System.

The suppressed consumption is estimated at 65 % of the net water supply. Therefore 35 % of the net supply is lost in the distribution network. Furthermore, 5 % of the net supply (or 7 % of suppressed consumption) is lost through wastage at taps of individual consumers.

It is estimated that water consumption through registered connections accounts for 30% of net water supply, as is shown in Figure 3.10. Consequently 70% of the net water supply is unaccounted. The breakdown is given below:

Leakage	35 %
Illegal connections	29 %
No connections (standpipe/kiosk)	6 %
Total	70 %

FIGURE 3.10 WATER PRODUCTION, CONSUMPTION AND LOSSES (1990)



3.3.4 BUDGET FOR 1989-90 AND 1990-91 FISCAL YEARS

Table 3.23 gives the budget and the projections for the fiscal year 1989-90 and the budget for 1990-91, together with the performance of 1988/89. Tables 3.24 and 3.25 give the details of income and expenditure, respectively. The financial statements for 1989/90 have not been prepared.

TABLE 3.23 RECURRENT INCOME AND EXPENDITURE BUDGET (1989/90 AND 1990/91 FINANCIAL YEAR)

(Unit: T.shs. million)

	1988/89 (Actual)	1989/90 (Budget)	1989/90 July-Dec (Actual)	1989/90 July-June (Projection)	1990/91 (Budget)
REVENUE	933.1	1,162.5	309.6	842.9	1,016.5
OPERATING EXPENDITURE	472.9	1,009.6	400.4	932.0	1,756.8
DAR ES SALAAM BRANCH	.....	903.6	348.0	840.9	1,646.8
HEAD OFFICE	.....	106.0	52.4	91.1	110.0
DEPRECIATION *	31.9	90.4	34.8	84.1	164.7
PROVISION OF DOUBTFUL DEBTS	237.1				
TOTAL EXPENDITURE	741.9	1,100.0	435.2	1,016.1	1,921.5
SURPLUS (DEFICIT)	191.2	62.5	(125.6)	(173.2)	(905.0)
PRIOR YEAR'S ADJUSTMENT	(48.3)				
ACCUMULATED SURPLUS (DEFICIT)	(355.7)			(528.9)	(1,433.9)

* Estimated by JICA Study Team

As shown in Table 3.23, the performance of NUWA is projected to be unsatisfactory in 1988/89 fiscal year. Revenue is projected to be not only below the expenditures but also below that in 1988/89 fiscal year. The projected revenue is almost the same as the operating expenses of DSMB during the same period. The unfavourable performance in 1989/90 fiscal year mainly resulted from:

- Unsatisfactory reduction of illegal connections
- Lack of aggressiveness in follow up and recovery of arrears.

TABLE 3.24 INCOME BUDGET (1989/90 AND 1990/91 FINANCIAL YEAR)

(Unit: T.shs. million)

	1989/90 (Budget)	1989/90 July-Dec (Actual)	1989/90 July-June (Projection)	1990/91 (Budget)
Income from Operation				
Water Consumption				
Domestic	360.0			315.3
Institutional	99.8			106.5
Industrial	746.2			435.2
Commercial				166.1
Total Water consumption	1,206.0	296.3	822.7	1,023.1
New Connection Fee	10.7	4.5	6.9	4.3
Other Income from Operation	3.9	8.5	12.8	12.0
Other Income	3.0	0.3	0.5	1.9
Total Income	1,223.6	309.6	842.9	1,068.3
Less: 5% of Bills (Doubtful of Recovery)	61.1			51.8
Total Actual Income	1,162.5	309.6	842.9	1,016.5

TABLE 3.25 EXPENDITURE BUDGET OF NUWA DSMB (89/90 AND 90/91 FINANCIAL YEAR)

EXPENDITURE PROJECTION FOR 1989/90

(Unit:T.shs.thousand)

	Salary & wages	Pumping Cost	Filtration & Treatment	Examination of Water	Repair & Maintenance	Other Expenditure	Total
Intake & Treatment works							
Upper Ruvu	8,348	70,820	72,610	39	2,631		154,448
Lower Ruvu	6,081	186,449	265,637	15	11,571		469,753
Mtoni	5,573	10,911	22,094	0	1,909		40,488
Transmission of Treated Water							
Upper Ruvu to Kimara Reservoir					161		161
Lower Ruvu to University Reservoir					514		514
Kimara Reservoir			1,429		190		1,619
University Reservoir			13,598		24		13,622
Distribution of Treated Water	19,869				12,786		32,656
Booster Station							
G/M		244			0		244
Kunduchi		138			46		184
Lugalo		197			54		251
Vijibweni		240			0		240
Depot							
Pugu Road	11,082	34,721			2,161		47,964
Personnel & Administrative Expenditure	13,516	0			17,637	46,894	78,046
Financial Charge							
Bank charge						701	701
Total Expenditure	64,469	303,719	375,368	54	49,684	47,595	840,888

TABLE 3.25 CONTINUED

EXPENDITURE BUDGET FOR 1990/9/REVISED) (Unit:T.shs.thousand)

	Salary & wages	Pumping Cost	Filtration & Treatment	Examination of Water	Repair & Maintenance	Other Expenditure	Total
Intake & Treatment works							
Upper Ruvu	9,868	144,000	137,680	50	6,500		298,098
Lower Ruvu	7,618	238,800	736,110	50	13,500		996,078
Mtoni	5,752	24,000	43,840	50	9,500		83,142
Transmission of Treated Water							
Upper Ruvu to Kimara R.					300		300
Lower Ruvu to University R					600		600
Kimara Reservoir			11,610		700		12,310
University Reservoir			46,440		700		47,140
Distribution of Treated Water	24,994			250	24,210		49,454
Booster Station							
G/M		300			200		500
Kunduchi		300			200		500
Lugalo		300			200		500
Vijibweni		300			200		500
Depot							
Pugu Road	10,056	53,000			6,100		69,156
Personnel & Administrative Expenditure	14,894	0			26,000	46,880	87,774
Financial Charge							
Bank charge						750	750
Total Expenditure	73,182	461,000	975,680	400	88,910	47,630	1,646,802

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

Increases in pumping, filtration and treatment costs, and salaries and wages are expected to be 1.5, 2.6 and 1.1 times, respectively. Filtration & treatment costs and pumping costs amount to 59 % and 28 %, respectively, of the total expenditure of the DSMB.

In 1990-91, total expenditure for filtration and treatment is T.Shs 976 million, while revenue is expected to be T.Shs 1,016 million. Unit price and consumption of chemicals estimated in the budget are shown below.

TABLE 3.26 UNIT PRICE AND CHEMICAL CONSUMPTION IN 1989/90 AND 1990/91 FISCAL YEAR

	1989/90			1990/91		
	Unit Price (T.Shs.)	Consump-tion (Tons)	Amount (million T.Shs.)	Unit Price (T.Shs.)	Consump-tion (Tons)	Amount (million T.Shs.)
Aluminum Sulphate	66,300	5,610	371.9	90,000	6,850	616.5
Chlorine Gas	128,310	210	26.9	190,000	206	39.1
Sodium Carbonate	72,800	2,308	168.0	90,000	2,430	218.7

NUWA has forwarded a proposal for the revision of water tariff to the Ministry of Water, Energy and Minerals for consideration so as to ensure break-even operations. The proposed tariff is shown in Table 3.27.

TABLE 3.27 PRESENT AND PROPOSED TARIFF

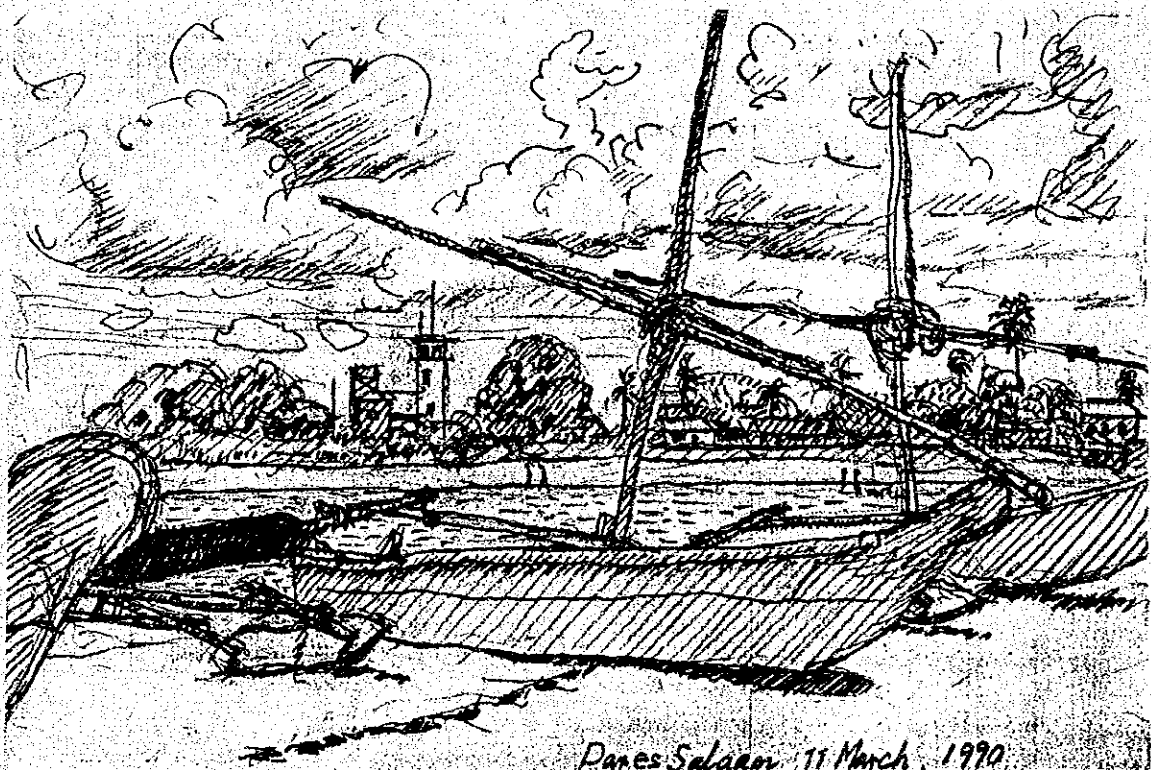
(T.shs.per 1,000 gallons)

Present tariff	Proposed tariff	Change	
Domestic	57.25	96.60	68%
Institutional	90.00	151.00	68%
Commercial	192.00	322.12	68%
Industrial	248.40	416.75	68%

The Ministry has not given its approval, as yet. The approval for revision is often delayed or granted at a lower level than that requested to cover increases in water production costs.

CHAPTER 4

WATER SUPPLY SYSTEM



CHAPTER 4 WATER SUPPLY SYSTEM

4.1 LOWER RUVU SYSTEM

4.1.1 OUTLINE

In 1976, the Lower Ruvu treatment plant was commissioned, together with transmission mains and new reservoirs in the City. It has a capacity of 182,000 m^3/day (40 mgd). However, the filtration unit has been out of service and consequently, production is 10% above capacity. Compared to the Upper Ruvu plant, it has the advantage of having larger dry-weather river discharge, due to a larger catchment area of 16,500 km^2. It also has the advantage of much lower pumping head and hence lower operational costs.

The physical alignment of the Lower Ruvu plant is shown in Figure 4.1, while its main features are shown in Table 4.1. The treatment plant comprises of the unit operations of flocculation and clarification to remove settlable and suspended solids, utilizing alum as the coagulant and, at times, activated silica as coagulant aid. Clarification is followed by rapid sand filtration.

Either liquid chlorine from one-ton cylinders or calcium hypochlorite solution is used for disinfection. As the water is aggressive in nature, sodium carbonate is used for pH control.

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

Nevertheless, at present, the Lower Ruvu plant has fewer problems than those at Mtoni and Upper Ruvu. The primary problem with this plant is the intake structure, where the intake radial gate is damaged (which is used to control the water level and prevent sand from entering to the plant). As a result, sand and molluscs from the river are freely entering with the raw water.

With regard to the filters, the underdrain system is damaged, the gates and valves are leaking and the control system is out of order. Consequently, the filters are now out of service. Chemical dosing and disinfection equipment, due to wear and tear over the years, are operating below their design capacities.

Based on the observations at the Lower Ruvu plant, the existing problems are analysed and possible solutions are planned and presented in Figure 4.2.

TABLE 4.1 OUTLINE OF THE LOWER RUVU SYSTEM

1.Intake Works
- Capacity : 5.0 m^3/s (85 mgd)
- Weir : reinforced concrete, delta cross-section across the river, with energy dissipaters and pool
  - width: 33.68 meters
  - top/crest EL: 3.658 m
  - bottom EL: 0.914 m
- Intake : Reinforced concrete, selective weir and channels. Sluice gated. Coarse bar screening

2.Intake Pipe
- Length : 105 meters (344 feet)
- Diameter : 54 inches(1350 mm)
- Material : Precast concrete pipe

3.Raw Water Pump Station
- Capacity : 2.5 m^3/s (42 mgd)
- Style : Gated, screened,duplex wells with sediment removal
- Pumps : Three,vertical mixed flow, 500 hp,1.1 m^3/s at 24 m head. Two units variable speed.

4.Raw Water Main(1)
- Length : 504 meters
- Diameter : 54 inches(1350 mm)
- Material : pre-stressed concrete pipe

5.Raw Water Main(2)
- Length : 75 meters and 80 meters
- Diameter : 48 inches(1200 mm), 2 parallel lines
- Material : pre-stressed concrete pipe

6.Rapid Mixer
- In-line mixing

7.Clarifier
- Capacity : 1.3 m^3/s (25 mgd) per tank, intermittent
  1.05 m^3/s (20 mgd) per tank, continuous
- Type : High-rate upflow solids contact
- Size : Reinforced concrete tanks. 38.1 m (125 ft) square, 5.5 m sidewater depth.
- Number : 2
- Equipment : Steel baffles, rotor-impeller mixer, bottom, scraper, launders, walkways, piping and sludge removal system

8.Filter
- Capacity : 2.1 m^3/s (40 mgd) at eight units
- Type : Gravity rapid sand. Air/water backwash. Weir flow rate controlled. False bottom underdrain.
- Size : Two bays per unit, 5.5 m to 14.6 m, Area 80.3 m^2
- Air Blowers:Three 1.23 m^3/s

9.Treated Water Pump Station
- Capacity : 2.1 m^3/s (40 mgd)
- Style : Above grade equipment, buried piping headers
- Pumps : Three, centrifugal, horizontal, single stage, double suction. Rated 1,900 hp, 1.05 cu.m/s at 108 m head. Two units variable speed by means of dynamic fluid drive couplings.

10.Chemical Feeding/storage
- Capacity : One month's supply, 1,390 m^2 space
- Equipment :Manual control
  Solution feeders(pumps) for alum,sodium carbonate, sodium bicarbonate, sodium silicate. Chlorine gas/solution, vacuum type chlorinators,ton containers, weighing scales,valves and metering.
- Tanks : Concrete, 3.5 m deep, duplex for min. 1 day use of chemical.
- - aluminum sulfate tank with mixer 2 No
- - sodium bicarbonate tank with mixer 2 No
- - sodium carbonate tank with mixer 2 No
- - sodium silicate tank with mixer 2 No

11.University Reservoir
- 5 mg (22,700 m^3) X 2 Nos

Details : refer to section 1, Appendix C.

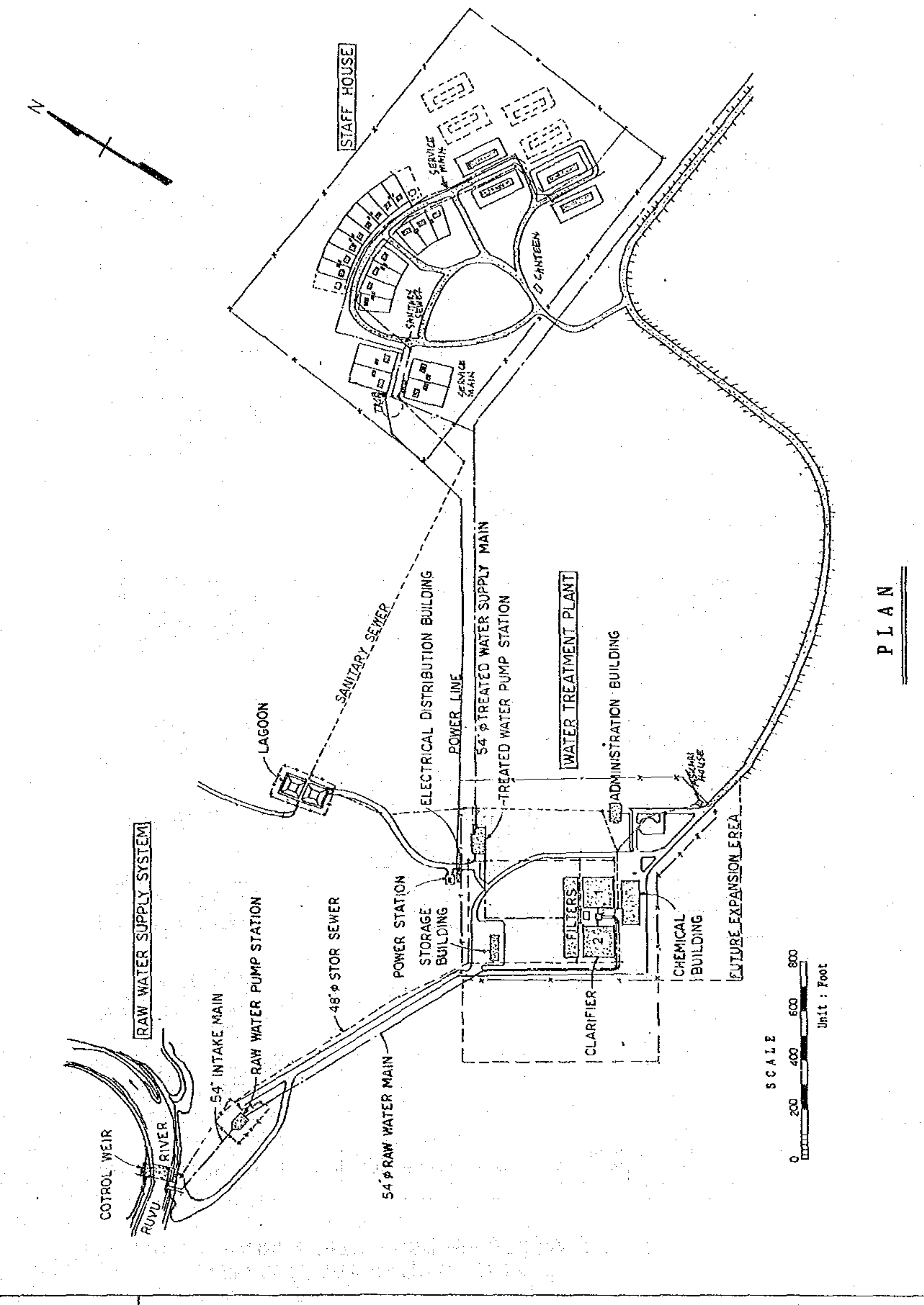


FIG. 4.1	PLAN OF LOWER RUVU TREATMENT PLANT

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

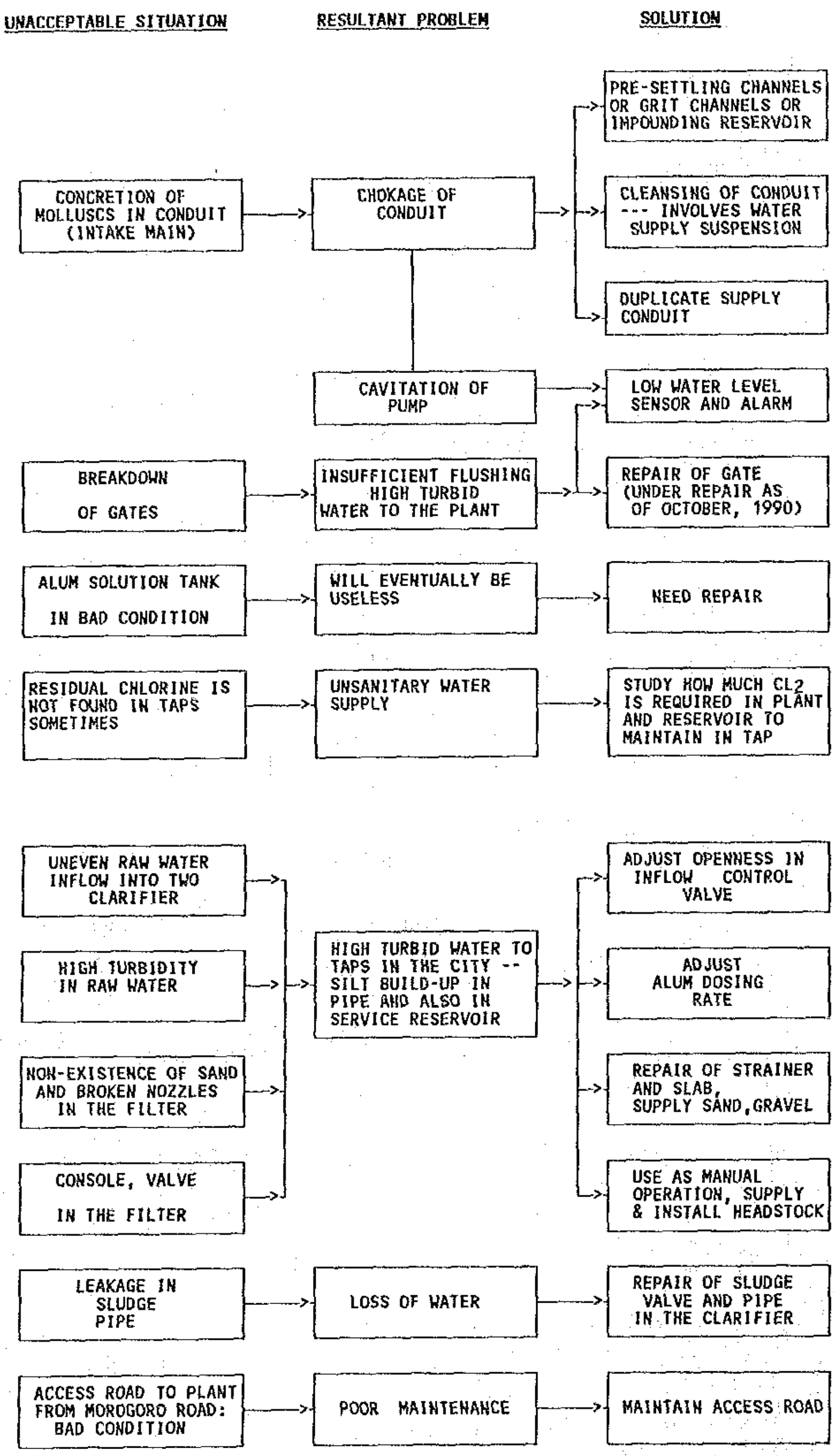


FIGURE 4.2 POSSIBLE REHABILITATION PROGRAMMES IN THE LOWER RUVU SYSTEM

4.1.2 HYDROLOGY

The impoundment of water by a weir across the Ruvu river downstream of the intake, provides sufficient depth of water and an assured supply to meet the design requirements of the treatment plant around the year.

4.1.3 PLANT OPERATION

(1) TURBIDITY

The Ruvu River water characteristics were derived from five raw water sample series taken by the Swedish consultants, Vattenbyggnadsbyran and Degremont prior to the design of the plant. The turbidity obtained from the tests ranged from 100 to 830 SiO_2 units. The raw water characteristics are shown in Table 4.2. The raw water contains large quantities of suspended solids - silt and sand. It also contains very fine non-settlable and colloidal particles. Particle distribution analysis conducted on October 6, 1990 confirmed this (see Table 4.3). The water, however, does not contain significant amount of organics.

The turbidity of the water varies widely during the year, as is shown in Figure 4.3, which also indicates the average monthly turbidity. In the rainy season, turbidity is high, while in dry season, it is low. However, even in dry season, it exceeds 100 JTU most of the time and this gives a relatively high annual average of 200 - 500 JTU. The highest turbidity recorded was 900 JTU in 1986. The plant, therefore, has been operated under an extremely high solids load throughout the year. Hence, continuous monitoring of the raw water quality is required to produce good quality water by adjusting the alum dosing rate.

Before the construction of the Lower Ruvu treatment plant, treatment plants in Tanzania such as the ones at Mtoni and Upper Ruvu had been built with small multiple upflow sedimentation units and rapid sand filters. The sedimentation units and filters were operated at relatively low loading rates, usually 480 gallons per day per square foot (1.6 meters per minute) and 1.5 gallons per minute per square foot (105 meters per day), respectively. The Lower Ruvu System has a loading rate of about 1,500 gallons per day per square foot (5.5 meters per minute) in the sedimentation basin and 150 meters per day in the rapid sand filters.

Alum, used as a coagulant, has to be imported, either against cash payment or through grant aid from foreign donors. It has often happened that no alum was available and this resulted in the production of water with high turbidity.

TABLE 4.2 RUVU RIVER RAW WATER CHARACTERISTICS

	Vattenbyggnadsbyran -Degremont	WHO(International Recommended Limits)*
Colour	14 - 400 units	5 units
Turbidity	100 - 830 units	5 units
Deposit	high - very high	
Odour	slight - strong moss	unobjectionable
Conductivity	210 - 338 μΩ/cm	
Taste		unobjectionable
pH	7.2 - 7.8	7.0 - 8.5
Total salinity	147 - 236 mg/l calculated	
Alkalinity	35 - 120 mg/l	
Chloride	26 - 44 mg/l	200 mg/l
Sulfate	3.8 - 5.8 mg/l	200 mg/l
Nitrate	2 mg/l	50 mg/l
Nitrite	0.01 mg/l	
Phosphate	0.32 - 1.0 mg/l	
Ammonium	0.4 - 0.1 mg/l	
Bicarbonate	43 - 146 mg/l	
Calcium	13 - 34 mg/l	75 mg/l
Magnesium	7 - 16 mg/l	50 mg/l
Zinc		5.0 mg/l
Copper		1.0 mg/l
Manganese	0.07 - 0.46 mg/l	0.1 mg/l
Iron	2 - 15 mg/l	0.3 mg/l
Total Hardness	62 - 135 mg/l $CaCO_3$	
Free Aggressive CO_2	5 mg/l	
Total Solids		500 mg/l
Phenolic Substances		0.001 mg/l

Quality of raw and treated water from February 1988 to June 1988 are shown in section 2, Appendix C. * WHO is the standard for drinking water.

TABLE 4.3 PARTICLE SIZE DISTRIBUTION IN LOWER RUVU RAW WATER (OCTOBER 6, 1990)

	Before vibration		After vibration	
Diameter (μm)	Difference (%)	Cumulation (%)	Difference (%)	Cumulation (%)
50.00	0.0	100.0	0.0	100.0
36.10	0.0	100.0	0.0	100.0
30.00	1.0	99.0	0.0	100.0
20.00	2.3	96.7	0.0	100.0
10.00	21.3	75.4	8.1	91.9
6.86	18.1	57.3	15.9	76.0
4.00	23.2	34.1	25.7	50.3
1.86	22.1	12.0	31.9	18.4
0.45	11.9	0.1	18.3	0.1
0.25	0.0	0.1	0.0	0.1

(Analysed by Dr. Yamada, JICA advisory committee member)
(Turbidity was 177.8 mg/l)

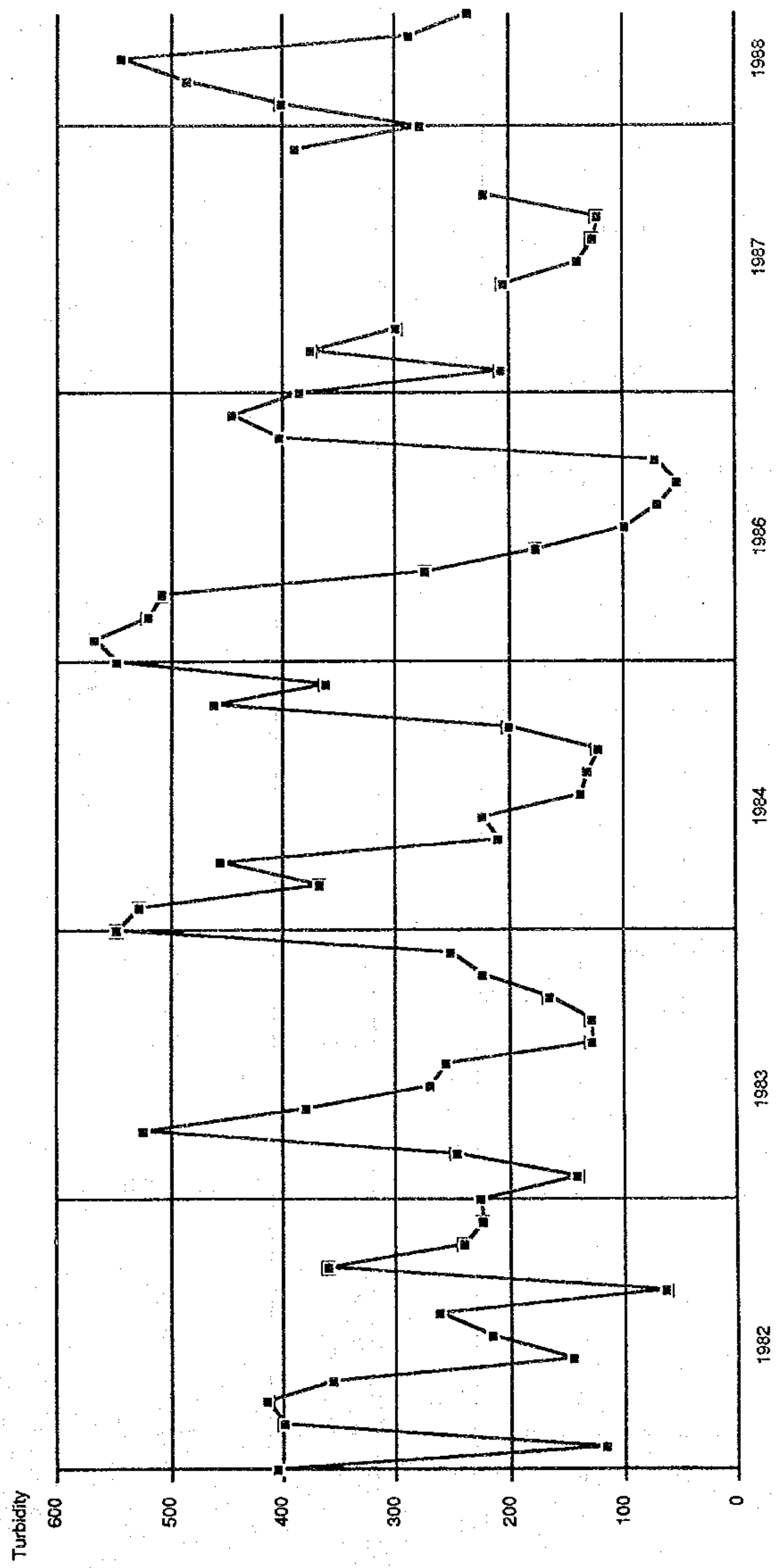


FIG. 4.3 MONTHLY AVERAGE TURBIDITY OF RAW WATER IN THE LOWER RUVU PLANT

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

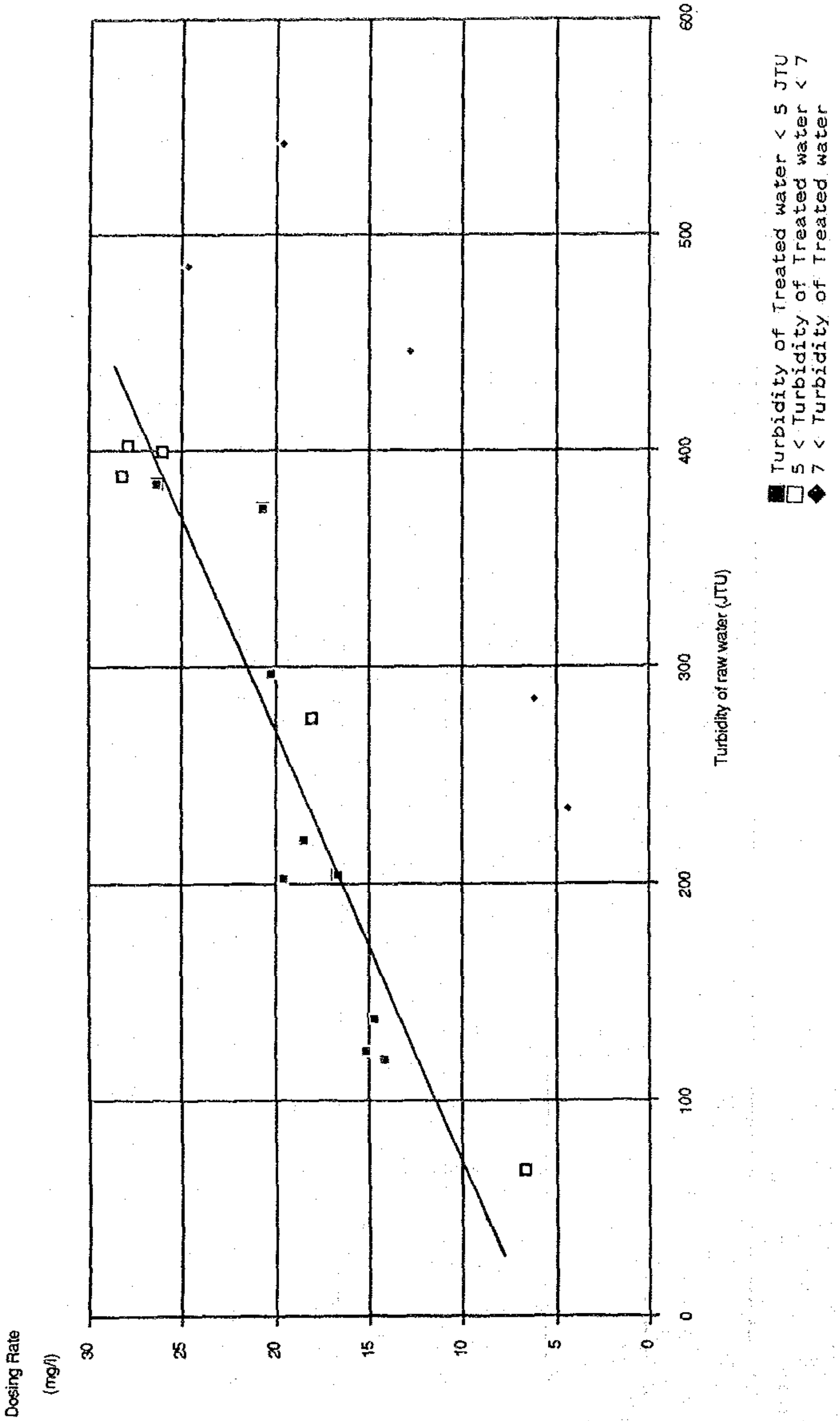


FIG. 4.4 DOSING RATE OF ALUM

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

Dosing rates of alum are from 5 to 30 mg/l. Usually, higher turbidity raw water requires higher dosage. The relationship between turbidity and alum dosage required is developed and illustrated in Figure 4.4. Dosage of alum required increases linearly with intake raw water turbidity upto 400 JTU. Smaller dosage rates than that given by this linear relationship produces a turbidity in treated water of more than 7 JTU; while dosages equal to or larger than that given by this linear relationship produces water with turbidity less than 7 JTU.

(2) WATER-AGGRESSION CONTROL

The water flowing through the plant up to the filtration process is aggressive in nature, and will attack metals, the cement component of concrete, and other such materials.

The treatment process includes the addition of sodium carbonate as a post-filtration chemical agent to reduce or nullify the aggressive nature of the filtered water. The continued use of such a chemical is vital to;

(a) avoid deterioration of the mortar lining of the main high pressure trunk main, the overall distribution system, and the commercial, residential, and industrial appurtenances conveying water, and
(b) to maintain the anticipated high water quality produced at the Lower Ruvu plant up to the doorstep of the consumer.

Failure to continue aggression control will result in water quality at the consumers' taps having little resemblance to the treated water leaving the treatment plant. The aggressiveness of the water causes it to pick up, by dissolution, metals and other materials from the piping and fittings through which it passes, such as iron, manganese, lead, etc. Not only is this a health hazard, it can also cause discoloration and cloudiness in the water. However, this aspect of the treatment process does not inhibit the plant process capacity in any way.

Alkalinity in raw water ranges from 80 to 100 mg/l. Alkalinity is low when turbidity is high and vice versa (see Fig. 4.5). This is disadvantageous for coagulation where more alkalinity would be consumed by the high dosing rate of alum, resulting in low pH, which would adversely affect proper coagulation. Care must, therefore, be taken to control pH, particularly during periods of high raw water turbidity in order to effectively remove suspended particles.

(3) CHLORINATION

Residual chlorine in the treated water is maintained at around 1 mg/l. This is necessary as there are consumers between the plant and the University reservoir. The residence time in the transmission main

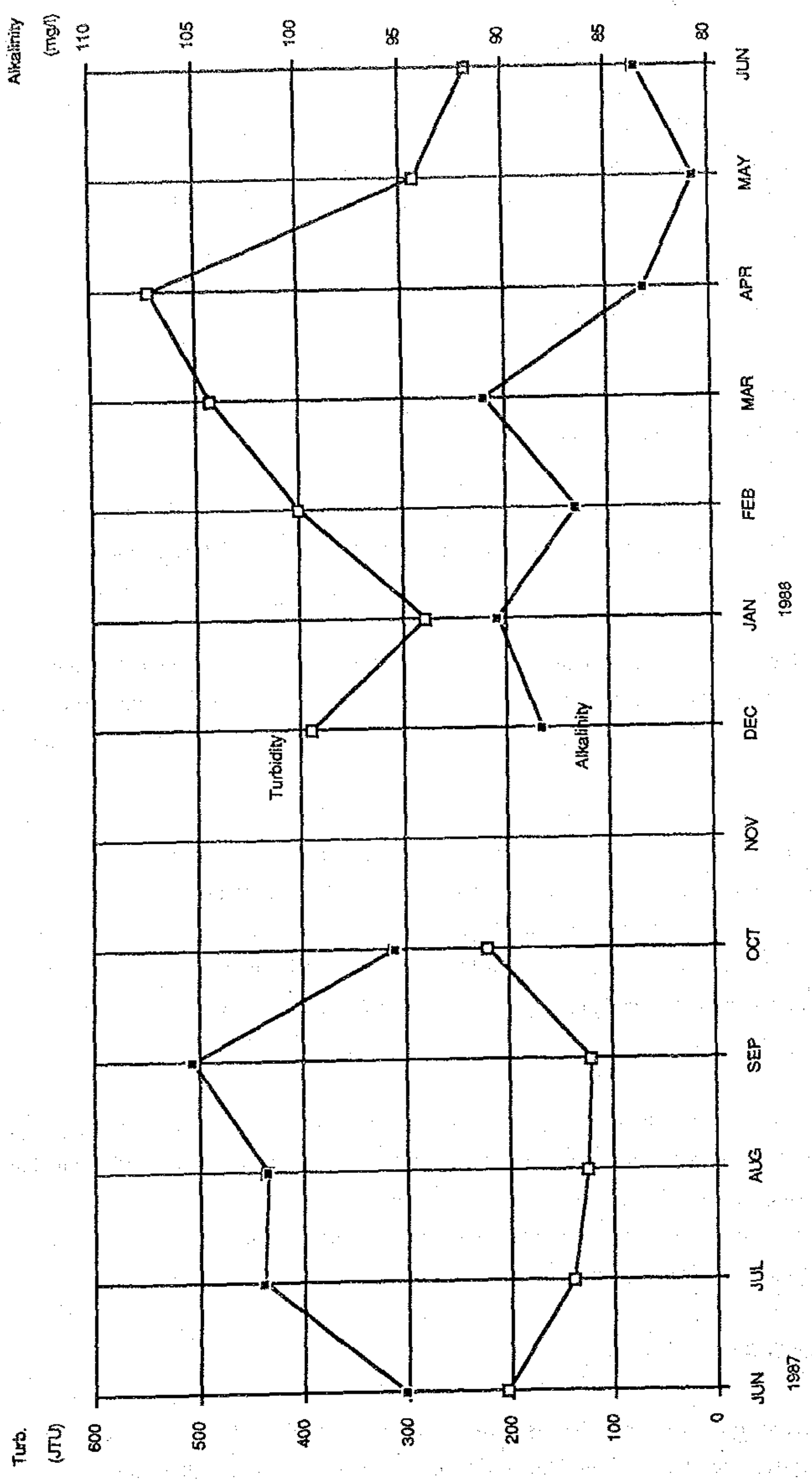


FIG. 4.5	RELATION BETWEEN TURBIDITY AND ALKALINITY OF RAW WATER

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

at 40 mgd plant output is about 11 hours. Hence, it is apparent that further chlorination at the reservoir is necessary to help maintain a residual throughout the distribution network.

However, residual chlorine in the tap water in the city is often not detectable. Thus it is necessary to evaluate the quantity of residual chlorine required in the stream leaving the treatment plant and at the reservoir, so as to maintain sufficient residual chlorine in tap water, both in the city and areas along the transmission main.

4.1.4 FACILITIES

(1) CONTROL GATE IN INTAKE STRUCTURE

The two radial gates, one each on the intake channel discharge and on the intake by-pass channel, appear to be in disuse, with only one visible on the river bank. The radial gates or its substitutes have to be rehabilitated in order that sufficient differential head across the gates be made available to provide adequate flushing velocity. Otherwise, partial choking in the intake screens and deposition of sand and silt in the gravity supply conduit will take place.

To remedy this, it is suggested that the existing radial gates are removed and replaced with a simpler stop log. A chain hoist should be installed on the upper part of the stop log, so as to enable the stop log to go up and down. This proposal has incidentally been adopted by NUWA already and a stop log is being constructed as of October, 1990.

(2) GRAVITY SUPPLY CONDUITS

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

It appears that molluscs build-up has been taking place since the commissioning of the plant, and the only indication of the problem was the progressive reduction in the output capacity of the raw water pumps. When reduction in capacity was observed, it was followed by an inspection of the pumps, which indicated that there was severe corrosion/erosion or cavitation of the pump suction bell and its associated impeller.

A single underground closed gravity supply conduit is a rather risky proposition due to possible blockages and repairs, during which period, the supply to the treatment plant is totally cut off. A standby supply conduit may be one solution. This will guarantee uninterrupted water supply, in case one of the conduits is out of commission.

Alternatively, pre-settling channels similar to grit chambers could be located ahead of raw water pumping, as an extension of the present conduit to remove the high silt load. This will result in reduced suspended solids load and consequently, reduced alum consumption as well. Reduced suspended solids will also reduce the chances of clogging in the sludge pipes in the clarifier, reducing the chances of erosion of and hindrance to the movement of the scraper arms, especially during periods of high silt load in the raw water.

Construction of an impounding reservoir or a grit chamber is costly since excavation volume is four times as much as the reservoir volume, in case of a one week storage reservoir. This comparatively high excavation volume results from the inclined terrain between intake point and treatment plant. Therefore, an impounding reservoir is not economical and is not recommended. The planned grit chamber is to remove sand particles in the raw water, which range from 0.08 to 2.00 mm (μm) in diameter, as given in "Upper Ruvu Intake Problem".

Among the alternatives, laying additional intake main is economical. For ease of maintenance, open channel conduit is preferable. However, due to the same reason as an impounding reservoir, an open channel is too deep and hence costly and, hence, an underground pipe is proposed. The proposed diameter is 66", larger than the existing 54" in order to try to minimise occurrences of pump cavitation.

(3) RAW WATER (LOW LIFT) PUMPING STATION

Three pumps have been installed, each delivering 50 percent of the design capacity. Two of the pumps have a variable speed design through fluid coupling, which needs constant attention. The conversion of the horizontal drive to vertical is through oil cooled beveled gears.

A minimum working differential head of 6 inches (150 mm) is usually required for raw water pump screens and attention must be paid to cleaning the screens for washing at the maximum differential head.

The pump manufacturer, according to the operation manual, has recommended a water submergence of 6 feet (180 cm) for the pump units. This would require a minimum water level in the pump well of 7.5 feet compared with a pumping station main floor level of 26.0 feet.

Under conditions of lower water level in the river, the margin of safety between the recommended pump submergence and the resultant water level in the pump well is relatively small. If the river is at the crest level of 10.0 feet, the expected level in the pump well with screen losses under normal pump operations of two pumps would be 8.4 feet. This is in comparison with the manufacturers recommendation for a submergence of 7.5 feet.

Furthermore, the build-up of bivalve molluscs along the raw water main lower the intake rate. Inadequate flushing due to break-down of the control gate in the river also contributed to lowering the intake rate. Besides, sand and other suspended particles are carried into the plant along with the raw water intake because, currently, there is no grit chamber or a substitute in the plant. They are trapped in the fine screen of the pump well, lowering the intake rate. When this coincides with the low water level during the dry season, it is possible that pump operation is not stopped. This could lead to cavitation and damage the pump.

The pressure gauge and flow meters are neither in working condition nor properly calibrated. The silt gets deposited in the settling chamber and difficulties have been experienced with the ejector system when flushing out all the deposited silt.

Since there are no float gauges in the raw water pumping station, there is danger of excessive draw-down resulting in drastic damage to the raw water pumps. To rectify this situation, it is suggested that a new sensor be placed to detect the low water level. The type of sensor that should be installed is an electrode bar sensor, instead of a float switch sensor, for ease of maintenance.

(4) RAW WATER PUMPING MAIN

This pipe is in good working condition and is suitable for transmission at the design capacity.

(5) CLARIFIER

High turbidity water results in production of large quantities of sludge in the clarifiers. Without effective sludge removal, clarifiers cannot run efficiently. Poor sludge withdrawal leads to sludge accumulation and a reduction in the effective volume of the clarifier. This further leads to increasing the load on the clarifier, which produces an adverse effect on the quality of settled water.

The timer setting valves are not working. The height of the slurry pool in the settling zone has, therefore, to be maintained manually.

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

There are two equal size units to handle the influent. This indicates lack of flexibility in operation. When one clarifier is taken out of service or becomes out of order, the other unit has to be overloaded to 100 percent of its capacity.

Flow measurement of the treated water from the clarifiers have been made in August, 1990 and the results from the records are given below. The volume of water treated approximately equals the volume of water intaken. The flow rate is, however, about 15 % greater than the design flow rate of the basins. There is some imbalance in the amount of water treated by the two sedimentation basins.

(1) Design Flow of Treated Water

40 mgd = 181,840 m^3/d

(2) Intake Pump Record

Pump	No. 1	740 l/sec	
	No. 2	580 l/sec	
	No. 3	1,100 l/sec	
TOTAL		2,420 l/sec	(209,088 m^3/d)

(3) Flow rate of settled water from sedimentation

Sedimentation Tank No.1	No. 1-1	52,272 m^3/d
	No. 1-2	58,320 m^3/d
	Sub-total	110,592 m^3/d
Sedimentation Tank No.2	No. 2-1	49,680 m^3/d
	No. 2-2	48,125 m^3/d
	Sub-total	97,805 m^3/d
	TOTAL	208,397 m^3/d

(4) Water Conveyance Flow

Pump	No. 1	-	
	No. 2	1,200 l/sec	
	No. 3	1,180 l/sec	
TOTAL		2,380 l/sec	(205,632 m^3/d)

(6) FILTER

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

It was suspected that the existing strainer nozzles had become clogged by sand. For instance, in 1980/81, unsettled water was sent through the filters due to a shortage of coagulant. Particles that pass through the strainer into the clearwell can only be pushed back into the strainer during the backwash cycle. In addition, at least one of the underdrain plenum slabs is dislocated.

The rate control valves, which protect the filters from excess backwash water, were not working. Uneven distribution of flow during backwash was observed in the past, and this may be due to clogging and breakage of the nozzles in the false bottom.

In addition, the hydraulic cylinders used to operate the sluice gates for both the incoming settled water and the washwater drain in the filters have deteriorated to the point that the cylinders can no longer be properly opened with the available water pressure. Effluent flow rate controllers are not in working condition. Considerable leakage is observed through valves in the filters.

Automatic operation of equipment should be abandoned and be replaced by manual operation with the use of existing equipment. Rehabilitated mechanical and electrical machinery will be simple to operate and particular attention will be paid to ensure that they are of high durability. From the viewpoint of operations and maintenance, it will be organized in such a way that it is easy to inspect and examine, and that repairs are easy to perform.

1) "Winfila" Nozzle Assembly

Reuse of "Winfila" nozzle assembly will be very difficult and the entire nozzles should be replaced by a new one. Underdrain plenum slabs also need to be repaired.

2) Sand

At present, sand from the filter has been removed from the filter unit and placed in an area outside. Bush, shrubs and other wild vegetation have grown on it and in its present state, reuse may be difficult. If it is to be reused, it should be screened and washed. Some sand will be lost and this should be supplemented by new sand. Sand from the Mpiji river between the plant and DSM along the Bagamoyo road can be used. Approximately 15 percent in volume of new sand will be needed for the filter.

3) Valve

Hydraulically-actuated valves from the filter console are not in working condition although most of them can be operated manually. For breakdown-free operation, manual operation is recommended, once the filter is rehabilitated. In such a case, the number of filter operators should be increased, since at least two operators are required in filter washing. Headstock is added to the inlet valves to enable them to be manually operated.

(7) CHEMICAL EQUIPMENT

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

Anti-corrosion material have become detached from the inside surface of the alum solution tanks and, damaged areas need to be repaired. Tar-epoxy resin will need to be painted.

Mixing impellers in the in-line mixers for aluminium sulphate and pre-chlorination are not working. Mixing of both chemicals has long been performed without mechanical mixing, but with just the effect of high velocity inflow from low-lift pumps.

The pipes and pressure-reducing valves between the chlorine gas container and chlorinator have corroded and need to be replaced with new ones. Steel pipes with polyethylene powder should be used.

(8) CHLORINATION

Water supply pumps have been out of order. Instead, water has been taken from the approximately 30 meter pressure pump which lifts water to a small roof reservoir for filter backwashing. This practice was working well as of October, 1990. Besides, spare parts for the water supply pump were already in the plant and therefore, the pump is expected to be operational soon.

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

(9) ELECTRICITY

The main electric supply is through one overhead TANESCO feeder only. There are frequent power supply suspension and, as a result, frequent water supply suspension. NUWA has already ordered another feeder from TANESCO but, unfortunately work has not yet been completed. Discussion with TANESCO, which is a parastatal organization under the Ministry of Water, Energy and Minerals should be expedited.

(10) WATER QUALITY TESTING EQUIPMENT

At present, the following equipment is available for water quality analysis and is sufficient;
- jar tester
- water distiller
- comparator for residual chlorine and pH
- test tubes, beaker (1,000ml) and flask (250ml)

Bacteriological analysis are conducted in the laboratory of Ministry of Water, Energy and Minerals whenever required.

(11) CLEAR WATER STORAGE

The clear water storage tank is in good working condition. It can store water flowing at 40 mgd for 30 minutes, which might be low for pump operation.

(12) CLEAR WATER PUMPING STATION

The three available pumps can each discharge half the design flowrate. There is thus very little flexibility in daily operations.

(13) CLEAR WATER PUMPING MAIN

There are at least 16 off-takes ranging in size from 4 to 10 inch in diameter from the transmission mains between the Lower Ruvu treatment plant and the University reservoir. It is estimated that the 16 known take-offs utilize at least 17% of the plant output under normal operating conditions, with only the remaining 83% being delivered to the University reservoir.

There is no proper all-weather access road along the rising main for routine inspection, patrolling and repairs.

(14) ACCESS ROAD

At present, access road to the plant from Morogoro Road is unpaved and is in quite a bad condition. During the rainy season, a part of the road becomes difficult to traverse. Given that this road is to serve for the transport of chemicals, machinery and other materials, it would be necessary that this road is improved.

(15) UNIVERSITY RESERVOIR

The two 5 million gallon reservoirs are always empty due to the demand on the system exceeding water production.

The main operational task is to close the outer valve of all the reservoirs at night so that there is sufficient water build-up during the non-supply hours. This will enable better supply and higher operating pressures during supply hours. This, however, is not done because, 1) filling of individual household tanks in residential areas with water during night period is required in some areas and 2) air-lock has once taken place in the distribution system, supposedly due to the lack of air valves. Further, operation of large sluice outlet valves will require time and labour.

4.2 MTONI SYSTEM

4.2.1 OUTLINE

The Mtoni plant, which is very small and very old, is located in the south of the city, approximately 7 km from the city centre, along Kilwa road. The flow diagram of the Mtoni treatment plant is shown in Figure 4.6, while its main features are given in Table 4.4.

TABLE 4.4 OUTLINE OF MTONI SYSTEM

1.Intake Structure
  Weir, infiltration gallery
2.Raw Water Pump
  - 5.25 m^3/m X 55.5 m X 110 kw X 1,470rpm X 400v X 2 No, Vertical type, 250mm dia.
  - 4.50 m^3/m X 55.9 m X 75 kW X 1 No, Horizontal centrifugal type,single impeller
3.Low-lift Rising (Transmission) Main
  15 inch (375 mm) diameter, about 3 km
4.Coagulation/Flocculation Basin
  Horizontal zig-zag flow, Galvanized-Steel structure
5.Upward Flow Sedimentation Basin
  55.7 m^2 X 6 Nos. Reinforced concrete structure
6.Filter
  Rapid sand filter, 28 m^2 X 3 Nos., Reinforced concrete structure
7.Chemical Dosing
  -Alum (aluminium sulfate) as coagulant
  -Activated sodium silicate, 2 feeder pump, 2 solution tank with agitator
  -Alkaline agents, gravity feed to filtered water
  -Post-chlorination (chlorine gas or calcium hypochlorite), solution tank, gravity feed to filtered water
8. Underground water tank
  2 million gallon (9,100 m^3) reinforced concrete
9. High-lift Pump
  -5.46 m^3/m (1,200 gpm) X 36.6 m X 55.0 kW X 2 No. for city
  -2.27 m^3/m (500 gpm) X 35.1 m X 2 No. for Mbagala

Raw water is initially delivered to a baffled mixing race (coagulation basin) where aluminum sulfate is added. However, instead of the original baffled mixing race which is still in place, a horizontal zig-zag flow flocculation basin that was later added is now in use.

The mixture is then delivered to six hopper-bottom, vertical flow clarifiers which are designed to utilize a single blanket for flocculation/ clarification.

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

The water is then treated with soda ash to adjust the pH and chlorinated before being discharged to a

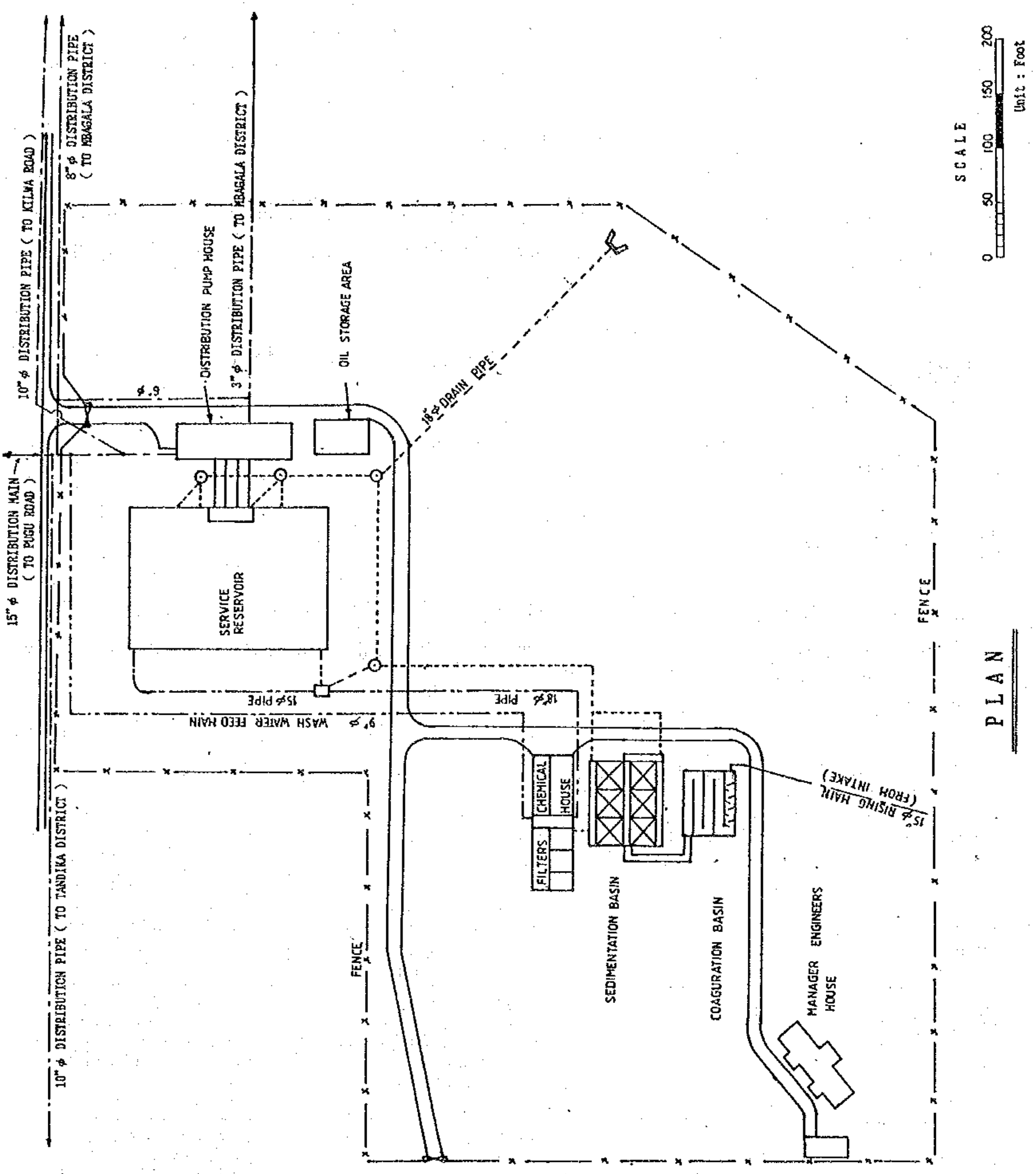


FIG. 4.6	PLAN OF MTONI TREATMENT PLANT

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

9,100 m³ (2.0 million gallon) storage reservoir. The storage water level is 131 feet (39.9 m) and the water must be pumped to the distribution system. The initial capacity of the pumping station was 8,550 m³/day (1.88 mgd). The pumping station also functions as a booster pumping station for areas further south of Mbagala, and to supplement supply to the southern areas with water from the Lower zone.

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

The required rehabilitation work is presented here. Figure 4.7 illustrates the resultant problems and possible solutions.

4.2.2 WATER SOURCES [1]

(1) CURRENT WATER SOURCES

There are three or four water sources, one of which is presently still under use, while withdrawal from the other sources have either been suspended or have been abandoned. The sources and their respective locations are shown in Table 4.5 and Figure 4.8.

TABLE 4.5 WATER SOURCES FOR MTONI TREATMENT PLANT

Intake Weir (Kizinga)	1952 -- present	Under Operation	- Intake 1.7 mgd - 0.3 mgd in dry season - No technical information - No Operational Record
Infiltration Gallery (Yombo/Kilungule)		Out of Operation # Clogging and break of collecting pipe	- No technical information - No Operational Record
Impounding dam (Kilungule)		Out of Operation # Break of Embankment # Break of Intake Tower # Break and clogging of transmission pipe	- No technical information - No Operational Record - Said to be constructed as a pilot dam for checking seepage, but no further information is available.
Intake Weir (Mbagala, Mzinga)		All facilities were taken away in 1966	- This information was obtained from a former worker for Mtoni plant, but has not been confirmed officially.

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1. Details are presented in Appendix C.3

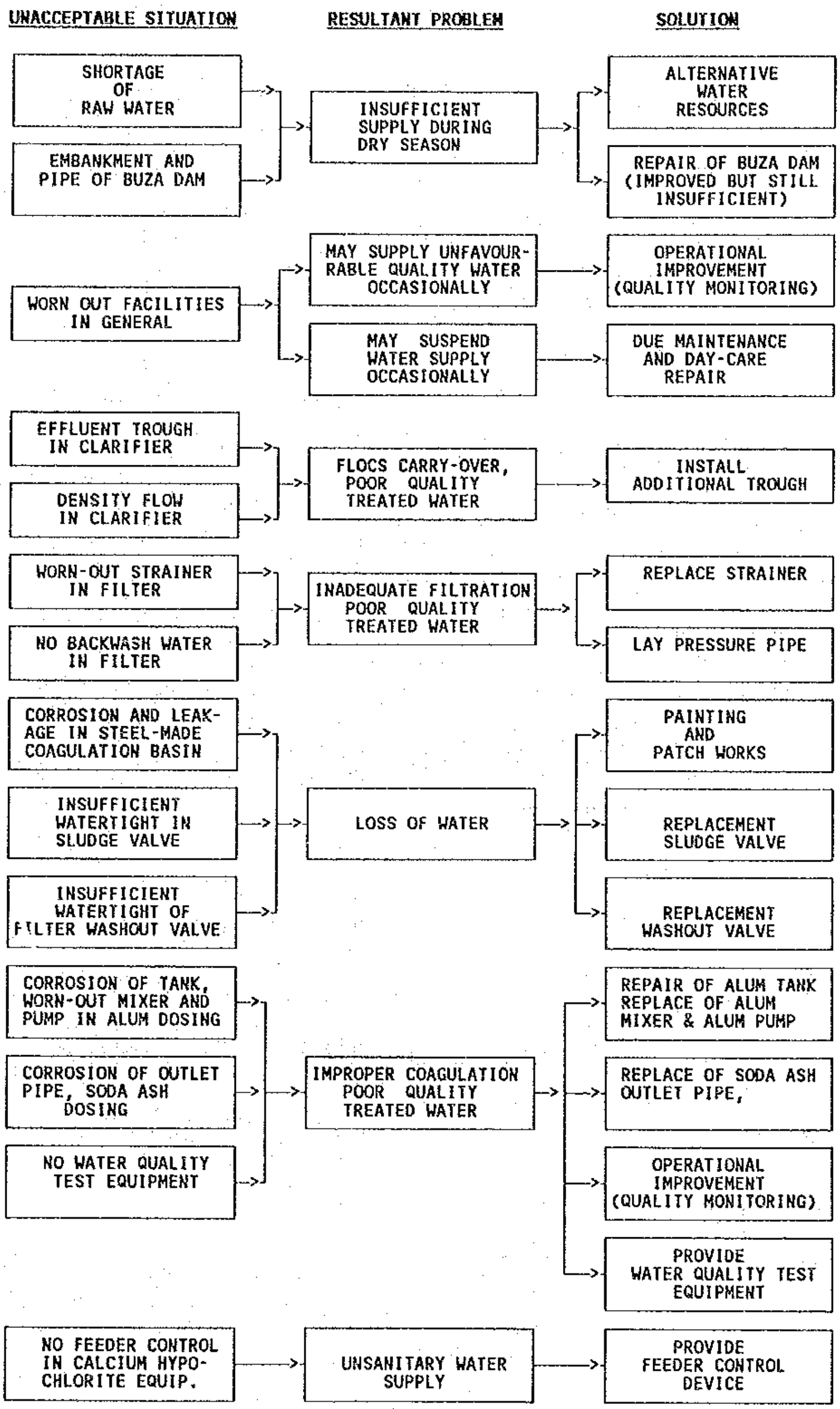


FIGURE 4.7 POSSIBLE REHABILITATION PROGRAMMES IN THE MTONI SYSTEM

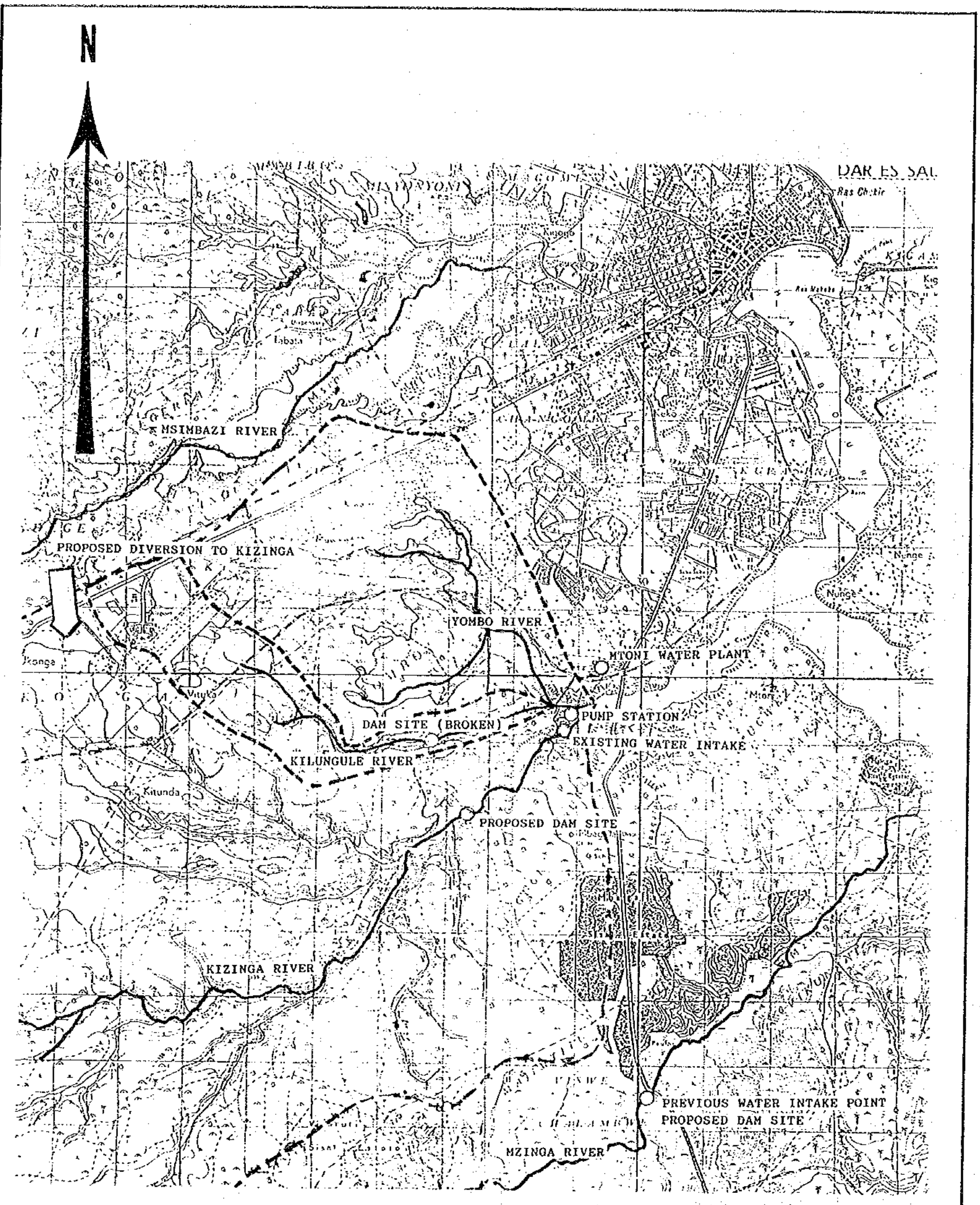


FIG. 4.8	LOCATION OF MTONI WATER SOURCES

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

SURFACE WATER FROM KIZINGA RIVER

Water from the Kizinga river is the only source currently used for the Mtoni plant. The intake structure is a concrete chamber with a wooden weir. No river level control and no flow control valves are available. No record of the amount of water intaken is available. According to NUWA, however, the daily intake volume is 7,700 m^3/day (1.7 mgd) during the wet season and this decreases to 1,400 m^3/day (0.3 mgd) during the dry season.

YOMBO AND KILUNGULE INFILTRATION GALLERY

The planned and the actual intake rates from the infiltration galleries in Yombo and Kilungule rivers during the earlier times are not known, but an intake water shortage was reportedly experienced soon after. In the early 60's, a small dam (Buza dam) was constructed on the Kilungule river and the water so impounded was used to supplement the supply to overcome the shortage. However, the embankment of the dam broke due to erosion caused by overflow.

Few details are available regarding these galleries, except the pipe laying drawings, along the stream to the pump station. Most junction wells were found to be filled with sand and covered with plants in January, 1990. Galleries were also judged to have been out of operation for quite a long time.

BUZA DAM

The dam embankment has been eroded in a V-shape, 10 m in width at the top. A concrete water intake tower exists about 20 m away from the top of the dam, near the left bank. No major damage was observed to the structure by visual inspection, but the attached equipment, such as pipes and valves, were found to be severely corroded. Water upstream of the dam was observed in January 1990 to flow out through the conduit drain across the bottom of the embankment.

Water was conveyed by gravity to the intake pump station through a pipeline. Most junction wells were found to be clogged with sand and covered with plants. The pipes that were buried under the riverbed were exposed by erosion of the bed at many locations, and many of the pipes were broken, It is, however, apparent on observation that repairs to these structures would be difficult.

INTAKE FROM MZINGA RIVER

According to information from a retired employee of NUWA, there was probably an intake from the Mzinga river in the early 60's. Water was lifted by diesel-driven pump(s) from the foot of the Mbagala bridge to the Mtoni plant through a pipeline along the Mbagala road. No further details are available.

(2) POSSIBLE INTAKE OF EXISTING WATER SOURCES

Any rehabilitation work would be worthless if the plant does not have enough water intake to meet plant capacity. Therefore, the existing information was reviewed to investigate the actual water intake capacity at present.

WATER INTAKE FROM KIZINGA RIVER AND BUZA DAM

Water intake from the Kizinga river alone would hardly be sufficient during the dry season in most years for operating the 2 mgd Mtoni plant. The Buza dam in Kilungule river, once rehabilitated, will yield 0.45 mgd in a 10-year return drought year, which is too little. The combined effect of these two intakes, however, will improve the amount of water available for intake, although even together, the water requirements for Mtoni cannot be met. (see section 3, Appendix C)

TABLE 4.6 EXPECTED EFFECTS OF KILUNGULE DAM

Effect	Existing Intake (only from Kizinga)	Intake from Kilungule (combination with the Kizinga)
No.of months to fail to intake 2 mgd (Probability)	25 (26.0 %)	11 (11.5 %)
Average intake whole period	7,927 m^3/day (1.74 mgd)	8,585 m^3/day (1.89 mgd)
Average intake in month to fail to intake 2 mgd	4,962 m^3/day (1.10 mgd)	7,509 m^3/day (1.65 mgd)

(Based on the simulation from 1968 to 1975)

INFILTRATION GALLERY

Development of infiltration galleries is not worthy of consideration because a) in the past ,the planned water intake failed soon after the start of operation b) the catchment area is so small that high yield is not expected and c) permission to use of groundwater in and near the area has already been denied in previous studies.

(3) ALTERNATIVE WATER SOURCES

Several studies have been conducted for expansion of the DSM water supply system to meet growing demands of the city since the completion of the Mtoni system. Alternative water sources investigated for the Mtoni plant are shown in Table 4.7. These studies were not necessarily for intake supplementation, and some were geared towards expansion of the plant capacity. Each alternative is reviewed here to evaluate its feasibility in supplementing the supply shortfall existing presently.

UNDERGROUND WATER

Ground water suffers from high salinity and hardness, increasing in proportion to increasing intake volume. In fact, availability of groundwater is reported to be extremely low within a radius of 50 to

TABLE 4.7 ALTERNATIVE WATER SOURCES FOR MTONI TREATMENT PLANT

Source	Description	Conclusion
Underground Water	Deep well, Shallow well, Infiltration	Not available within a radius of 50 - 80 km from Dar es salaam and within depth of 3,000 - 4,000 feet
Diversion of Msimbasi water to Kizinga	A certain portion of water of Msimbasi is pumped to Kizinga to increase its flow in dry season.	Details of the idea is unknown, but diversion is concluded as not feasible because of a) silting of aqueduct b) possible opposition from cultivators c) worsen the foul condition of the river.
Kizinga Dam	New earth-fill dam construction on Kizinga river	Storage;3,500 mg (15,900,000 m³) Possible water supply; 4.75mgd (21,600 m³/day) Initial dam cost; 941,000 UK pounds (1967)
Mzinga Dam	New earth-fill dam construction on Mzinga river	- PLAN A - Storage;7,400 mg (33,600,000 m³) Possible water supply; 10mgd (45,500 m³/day) Initial dam cost; 2,422,000 UK pounds(1967) - PLAN B - Storage;9,500 mg (43,200,000 m³) Possible water supply; 17mgd (77,300 m³/day) Initial dam cost; 48,440,000 UK pounds(1970)

80 km from DSM and at depths of up to 3,000 to 4,000 feet. Considering this situation and that historically shallow wells have been abandoned, it can be stated that ground water is not proper for the Mtoni water intake.

DIVERSION FROM MSIMBAZI RIVER TO KIZINGA

A report prepared in 1967 studied the feasibility of pumping water from the Msimbazi river, which is located next to the Kizinga river, through the City to supplement the dry season flow of the Kizinga river. The report, however, concluded that this would not be feasible due to the following reasons:

- silting of the aqueduct
- opposition from cultivators downstream of the Msimbazi
- worsening the pollution level of the Msimbazi river.

DAM CONSTRUCTION ON KIZINGA AND MZINGA RIVERS

Both dams were studied as possible water sources for a new water works planned at Mbagala.

- Kizinga Dam -	Planned Supply	: 21,600 m³/day (4.75 mgd)
	Initial Cost	: Pound Sterling 941,000 (in 1967)
- Mzinga Dam -	Planned Supply	: 77,300 m³/day (17 mgd)
	Initial Cost	: Shs.48,440,000 (in 1970)

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

Nevertheless, from the viewpoint of obtaining cheap water resources, it would be useful to consider utilizing existing water resources from the Mzinga River, which can supply sufficient water throughout the year, with the exception of the dry season. Therefore, water resource development planning for the future should also consider this.

Depending upon the results of water resources development study, rehabilitation of Buza dam and/or expansion of the plant might become necessary.

4.2.3 PLANT OPERATION

(1) WATER QUALITY

Daily water quality analysis has not been conducted in the plant for more than 6 years because of the non-availability of the required laboratory apparatus, equipment and reagent. To monitor water quality, samples were collected and sent to the Soil and Water Laboratory of the Ministry of Water, Energy and Minerals, once or twice a month. The results of the analysis are shown in Table 4.8.

However, as the results of the water quality analysis were not sent back to the plant on the same day, they could not be utilized for feedback control of plant operational parameters. In addition, since the number of samples are small, it is difficult to determine the maximum and average concentrations of turbidity and its variation. Raw water turbidity is an important control parameter in daily operations.

It may be noted from Table 4.8 that raw water alkalinity is lower than in the raw water at Lower Ruvu plant. This would suggest the necessity for pH adjustment by alkaline dosing in the coagulation process.

In the Study, several samples were analyzed (see Table 4.9). Although these are insufficient to judge the representative water quality of Mtoni, high turbidity in the treated water appears to be due to improper coagulant mixing, flocculation and clarification.

(2) CHEMICAL DOSING

Alum and chlorine are currently used, while use of soda ash (as an alkaline agent) is sometimes suspended due to shortage, as well as due to periodic repairs being done to the chemical solution tanks and injection pumps. Table 4.10 shows the actual consumption rates of alum and chlorine and their calculated dosing rates for certain periods. The dosing rates of alum vary from 35 to 107 mg/l. The sufficiency of this dosing rate cannot be judged without conducting jar tests. However, these rates are higher than the ones used in Lower Ruvu despite the fact that raw water turbidities at Mtoni are lower than at Lower Ruvu. The higher rate may adversely affect coagulation by decreasing the pH.

Chlorine injection rates vary widely. This implies improper control of the dosing rate. In fact, it was observed during site inspections in January and February, 1990, that calcium hypochlorite solution is being injected without any flow control, by gravity flow from the solution tank.

TABLE 4.8 WATER QUALITY OF MTONI PLANT (1)

Sampling Date	9/24/86		11/26/86			11/28/86			12/2/86			8/20/87			9/11/87	2/26/88		
Sampling from	Raw	Reservoir	Raw	Sedimentation	Tap	Raw	Sedimentation	Tap	Raw	Sedimentation	Tap	Raw	Sedimentation	Tap	Raw	Raw	Reservoir	Tap
Turbidity (JTU)	145	15	7	0	0	32	0	550	50	28	25	...	...	...	...	35	20	15
Colour (Ptmg/l)	40	30	25	5	10	120	0	423	80	30	10	...	...	...	...	85	40	30
pH	7.2	7.3	7.2	7.3	7.0	7.6	6.9	6.9	7.5	6.9	6.7	7.3	5.5	7.3	7.8	7.4	8.1	8.0
Conductivity (μS/cm)	870	600	440	290	241	370	240	230	400	450	299	400	530	260	390	530	375	360
SS (mg/l)	...	...	5	0	0	180	...	30	...	...	...	480	3	0	...	...	...	...
Alkalinity ($CaCO_3$mg/l)	54	32	50	36	14	54	14	14	62	20	62	58	48	64	74	106	82	60
Hardness ($CaCO_3$mg/l)	138	102	85	71	67	60	55	53	70	84	55	101	130	90	140	64	116	116
Ca (mg/l)	20.4	21.2	24.0	24.8	13.6	16.0	13.2	17.6	19.6	12.0	14.4	18.8	30.8	17.2	23.6	17.2	22.4	10.4
Mg (mg/l)	15.1	11.9	6.1	2.2	8.0	4.9	5.3	2.2	5.1	13.1	4.6	13.1	12.9	10.4	19.7	3.9	14.6	8.3
Chloride (mg/l)	30.5	17.7	70.7	70.0	42.0	77.0	39.2	41.3	66.5	19.6	55.3	105.0	104.4	41.9	...	93.0	58.2	51.8
NH_4-N (mg/l)	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	...	...	...
Fe (mg/l)	0.04	0.05	0.06	0.02	0.03	0.09	0.02	0.30	0.09	0.05	0.03	0.06	0.01	0.00	...	...	...	0.03
NO_3-N (mg/l)	4.70	2.70	0.03	0.06	0.03	0.10	0.06	0.18	0.04	0.19	0.15	0.43	1.32	0.33	...	2.03	0.86	0.85
$KMnO_4$ (mg/l)	14.8	5.2	8.0	8.2	7.0	16.8	5.8	16.0	8.8	8.0	5.0	4.4	1.4	0.6	6.2	26.6	4.0	3.4

(Based on Physical and Chemical Water Analysis Reports by Soil and Water Laboratory)

TABLE 4.9 WATER QUALITY OF MTONI PLANT (2)

DATE	TURBIDITY		pH		CONDUCTIVITY		RESIDUAL CHLORINE
	Raw	Treated	Raw	Treated	Raw	Treated	
11/1/90	200	15	7.1	6.5	300	290	0.6
19/1/90	120	10	7.2	6.6	360	300	0.4
30/1/90	100	10	7.2	6.5	360	300	0.8

(measured by JICA Study Team)

TABLE 4.10 WATER OUTPUT AND CHEMICAL CONSUMPTION IN MTONI

Month/Year	Output (mg/month)	Chemical Consumption (kg/month) Alum	Gas Chlorine	Hypo-Chlorite	Chemical dosing rate (mg/l) Alum	Chlorine
SEP/1985	....	12,600	...	...	...	...
MAY/1986	....	0	...	...	...	...
JUN/1986	....	18,000	...	520	...	...
JUL/1986	....	16,900	...	405	...	...
AUG/1986	....	17,100	182	300	...	...
NOV/1986	35.3	17,100	450	.35	107	2.8
DEC/1986	49.9	16,600	176	...	73	0.8
MAY/1987	49.6	15,950	532	...	71	2.4
JUN/1987	60.6	16,800	305	...	61	1.1
JUL/1987	52.7	16,050	434	...	67	1.8
AUG/1987	40.6	14,100	282	150	76	1.5
SEP/1987	53.8	15,000	543	...	61	2.2
JAN/1988	49.3	15,000	594	200	67	2.7
FEB/1988	53.5	16,050	300	...	66	1.2
MAR/1988	61.0	15,400	250	...	56	0.9
APR/1988	59.7	15,200	300	...	56	1.1
MAY/1988	61.2	18,200	515	...	65	1.9
JUN/1988	57.4	0	468	285	0	1.8
JUL/1988	60.7	9,600	826	...	35	3.0
AUG/1988	26.3	7,800	774	50	65	6.5

(Based on the Monthly reports obtained from NUWA)

4.2.4 FACILITIES

At present, equipment at the Mtoni treatment plant are in a worn-out condition due to its aging.

(1) INTAKE WORKS

The intake works consist of small basin with a screen. The raw water flows by gravity through a 300 m long cast iron pipe to the low lift pump station in the Kizinga valley.

(2) LOW-LIFT PUMP STATION AND LOW-LIFT MAIN

Raw water is pumped to the treatment plant through a 15-inch transmission main. Low-lift pumps were replaced in July 1989. Apart from the existing station, the original pump station is also there, which is left unattended to.

(3) RECEIVING WELL AND COAGULATION BASIN

The receiving well serves to stabilize the water level through the raw water conveyance facility, as well as to measure the flow to the plant. The receiving well also functions as a dosing point for chemicals.

The coagulation basin is made of steel plates, and despite being protected against corrosion by plating and painting, it is severely corroded. Corrosion is in a very advanced state in the steel walls of the effluent open channel and is consequently leaking. If the operations are continued in the present state, leakage is bound to increase. From the functional and structural viewpoint, functions that are expected of coagulation basins like water level stability, flow rate measurement, diffusion of the added coagulant and promotion of proper floc formation cannot be expected. This unit operation is very important in the treatment of the water and therefore, this state of affairs will bear heavily on downstream water quality.

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

(4) SEDIMENTATION BASIN

Following chemical addition, mixing and coagulation, the heavy, well developed flocs are removed by settling in sedimentation tanks. This basin, therefore, serves to reduce the load on the subsequent filtration unit, regardless of the turbidity load of the raw water. Normally, sedimentation basins ensure settlement of big, heavier flocs, provide buffering action and discharge settled, chemical sludge out of the unit.

The effluent trough is designed to ensure that low turbidity, settled water is efficiently transferred from the basin, with least disturbance to the basin. Presently, due to corrosion, half the troughs have fallen out, making it very difficult to perform the above-mentioned functions. Out of six sludge valves, three are not water-tight. All six valves are to be replaced.

It is recommended that new effluent troughs be added. Even timber troughs or half-cut PVC pipe can serve this purpose.

(5) FILTER

Filters are the last stage of the treatment process, before disinfection. Therefore, the filtrate should be within the allowable turbidity level. Periodic washing of the filter media must be performed to avoid clogging of the filter. During filtration, floc membranes or sludge are trapped in the sand filter media and over a period of time lead to loss of head through the filter media as well as reducing the filtration ability of the media. Regular backwashing is, therefore, necessary. However, backwashing is not performed and only air scouring is performed nowadays since backwash water is not available. The pressure of wash water supplied through the distribution pipes should be of the order of 3.66 kgf/cm^2. New backwash pipes need to be laid from the pressured distribution pipes.

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

(6) ALUMINIUM SULFATE DOSING EQUIPMENT

This unit delivers chemical coagulant through an injector at the right concentration and dosage into the raw water. Age, wear and tear have taken their toll. The inside surface of the solution tank is very corroded and has to be repaired. Mixers, using timber rods as replacement, provide for make-shift operation. Hence, new mixers should be installed to replace old mixers. Stainless steel should replace steel in the rotary propeller. Currently, only one of the two dosing pumps is operational, and even this is highly worn out, due to age. New pumps should replace the old ones. It is preferable that new pumps are the variable dosing types, so that dosing can be adjusted depending on turbidity and influent flow, thereby saving considerably chemical costs.

(7) SODA ASH DOSING EQUIPMENT

The existing gravitational piping and valves are highly corroded. New pipes and valves should be of highly corrosion resistant and durable materials.

(8) DISINFECTION EQUIPMENT

Disinfection of potable water supply is done to render water safe for use. By disinfecting water, pathogenic organisms are destroyed. Residual disinfectant (residual chlorine) in the distribution system is to ensure safety of the water even if there is unexpected, accidental pollution of the water supply in transit to the consumer through the distribution system.

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

4.3 DISTRIBUTION SYSTEM

4.3.1 OUTLINE

The distribution system of the City is divided into two zones, one called the Upper Zone and serving the high elevation areas from the Kimara reservoir and the other called the Lower Zone and serving the low elevation areas from the University reservoir and the Mtoni system. Both the Upper and Lower zones are gravity-fed systems except the Mtoni system. In addition, there are 5 booster stations in the distribution system to serve small, remote or high areas.

NUWA does not have sufficient distribution pipe network maps and drawings. Currently available maps and drawings show primary distribution pipes on a 1:20,000 scale. The other available drawings show secondary and tertiary distribution pipes with diameters down to 75 mm diameter or less on a 1:10,000 scale. Besides these, there are drawings (1:5,000) covering parts of the city. All drawings, especially of the secondary and tertiary distribution system, have not been updated adequately, and are not integrated so that they give only general indication of the location and other details of the distribution pipes.

TABLE 4.11 OUTLINE OF SERVICE RESERVOIRS AND PUMPING STATION

1. Kimara Reservoir (Upper Ruvu system)
   - Volume : 34,000m³; 2 Nos 8,000 m³, prestressed concrete, circular, top water level 449 feet (136.8 m) and 1 No 18,000 m³, circular, underground, reinforced concrete (30m radius, 8.2m depth)
   - Chlorination equipment: for feeding calcium hypochlorite solution (oxidizer), 60 l/hr x 2 kg/cm² x 0.4 kw x 3 No.(1 No. as standby) feed pump, motor, solution tank, storage tank, mixer, control panel
2. University Reservoir (Lower Ruvu system): 45,400 m³; 2 Nos 22,700 m³ (5 million gallon)
3. Mtoni underground water tank: 2 million gallon (9,100 m³) reinforced concrete
4. Mtoni High-lift Pump: 1) 5.46 m³/min (1200 gpm) X 36.6 m X 55.0 kW X 2 No. for city
   2) 2.27 m³/min (500 gpm) X 35.1 m X 2 No. for Mbagala
5. Gongo la mboto booster pump station: Four pumps to serve the Pugu secondary school and the brick factory, constructed in the early 60s. The size of the pump house is 7.0 X 7.3 m.
6. Wazo booster pump station
   Two pumps for the cement factory, constructed in 1978. The size of the pump house is 3.0 X 3.0 m.
7. Kunduchi booster pump station
   4 pumps for the beach hotel, constructed in the early 60s. The size of the pump house is 7.0 X 7.3 m.
8. Lugalo booster pump station
   Two pumps for the barracks, constructed in the early 60s. The building is made of similar material as the one at Gongo La Mboto Pump Station. The size of the pump house is 3.0 X 3.0 m.
9. Vijibweni booster pump station: 2 pumps supplying water to Kigamboni.

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

Main (primary) pipes, as shown in Figure 4.9 and Table 4.12, are pre-stressed concrete, steel and cast iron/ductile iron pipes. Pre-stressed pipes were laid in the late 70s, at the time of commissioning of the Lower Ruvu system, while the other pipes were mostly laid before the 70s, when the Upper Ruvu system was commissioned. External corrosion of cast iron pipes (BS 78) is negligible with the coal tar (or bitumen) coatings being relatively damage free (see section 4.3, Appendix C). Joints are mechanical screw type, which also appear to be generally sound. Original service lines are made of galvanized mild steel and although there is some evidence of corrosion, they are generally in good condition.

Figure 4.10 and Table 4.13 give installation year of secondary pipes. In general, the older the installation year of the pipes, the older the areas were developed because the pipes were laid along with the development of the areas. The city center, the southern area (Mtoni, Chang'ombe, Keko and Kurasini areas) and the northern area (Oyster bay and Kinondoni areas) were covered by the water supply system in the 1950's. The remaining areas in Kinondoni between the city center and the Oyster bay area were covered in the early 60s. In the late 60s, under the development of the Lower Ruvu system, the western areas such as Magomeni, Manzese and Sinza were covered by the water supply system. Since 1970's, very few pipes have been laid.

Recent network expansion has been carried out using locally manufactured uPVC pipes. Upon inspection, these pipes are of poor quality, although they nominally conform to British Standard (BS 3505). Many pipes are affected by ultra-violet, making them brittle and discoloured. Joints are by rubber ring but the bell sockets are not integrally moulded. Instead they have factory solvent welded into place. This type of joint, when used elsewhere has proved to be particularly unreliable, with frequent longitudinal splitting of the socket or pipe.

Through discussions with NUWA staff, it appears that many pipes are of low pressure rating (Class B, max working pressure 60 m) which may well result in considerable problems, when the system becomes fully pressurized following rehabilitation.

It can be noticed in Table 4.13 that the length of PVC pipes is greater than that of cast iron pipes in newly-developed areas, i.e., Kawe sub-branch, while the reverse is true in areas of the remaining sub-branches that were developed earlier. Figure 4.12 shows the lengths of pipes, classified according to

TABLE 4.12 LENGTHS OF MAIN DISTRIBUTION PIPES

(Unit: meter)

Dia. (mm)	Material	Installation Year -60	61-65	66-70	71-75	76-80	81-85	86-90	Total
1350	PSCP (PRE-STRESSED CONCRETE PIPE)				0	3,130	0	0	3,130
1200	PSCP	0	0	0	0	6,195	0	0	6,195
1050	PSCP	0	0	0	0	3,940	0	0	3,940
750	PSCP	0	0	0	0	3,250	0	0	3,250
600	PSCP	0	0	0	0	1,530	0	0	1,530
SUB TOTAL		0	0	0	0	18,045	0	0	18,045
1350	STL (STEEL PIPE)		0	0	0	1,820	0	0	1,820
825	STL	0	0	0	0	0	0	940	940
700	STL	0	0	0	0	2,760	0	0	2,760
600	STL	0	0	0	0	8,770	0	7,650	16,420
550	STL	0	0	0	4,675	0	0	0	4,675
525	STL	17,450	4,570	0	0	0	0	0	22,020
450	STL	1,025	3,955	0	2,700	0	0	0	7,680
400	STL	1,975	0	0	8,790	0	0	0	10,765
350	STL	645	1,270	0	0	0	0	0	1,915
300	STL	0	1,630	0	0	0	0	0	1,630
200	STL	1,055	0	0	0	0	0	0	1,055
SUB TOTAL		22,150	11,425	0	16,165	13,350	0	8,590	71,680
400	CST (CAST IRON PIPE)			0	350	0	0	0	350
375	CST	5,900	7,700	0	0	0	0	0	13,600
335	CST	0	335	0	0	0	0	0	335
300	CST	3,195	0	4,560	5,845	0	0	0	13,600
250	CST	4,765	940	0	0	0	0	0	5,705
200	CST	23,005	415	0	1,595	0	0	0	25,015
150	CST	19,520	0	9,545	3,230	55	0	0	32,350
100	CST	2,640	0	545	0	0	0	0	3,185
SUB TOTAL		59,025	9,390	14,650	11,020	55	0	0	94,140
800	DI (DUCTILE IRON PIPE)			0	0	0	0	4,100	4,100
400	DI	0	0	0	5,200	0	0	480	5,680
350	DI	0	0	0	0	4,835	0	0	4,835
300	DI	0	0	0	9,060	0	0	0	9,060
250	DI	0	0	0	6,220	3,770	0	0	9,990
200	DI	0	0	1,255	0	0	0	0	1,255
150	DI	0	0	0	1,145	0	0	2,025	3,170
SUB TOTAL		0	0	1,255	21,625	8,605	0	6,605	38,090
400	FGRP (FIBER GLASS REINFORCED PIPE)				0	0	0	3,175	3,175
SUB TOTAL		0	0	0	0	0	0	3,175	3,175
200	PVC(POLY-VINYL CHLORIDE)			2,430	345	4,015	0	0	6,790
SUB TOTAL		0	0	2,430	345	4,015	0	0	6,790
75	GP (GALVANIZED STEEL PIPE)				5,000	0	0	0	5,000
SUB TOTAL		0	0	0	5,000	0	0	0	5,000
TOTAL		**81,175**	**20,815**	**18,335**	**54,155**	**44,070**	**0**	**18,370**	**236,920**

(Pipe drawings: refer to Figure C.4.17, Appendix C)

TABLE 4.13 LENGTHS OF SECONDARY DISTRIBUTION PIPES

(unit:meter)

SUB-BRANCH NAME	Dia. (mm)	Material	Installation Year -60	61-65	66-70	71-75	76-80	81-85	86-90	TOTAL
ILALA	75	CI	4,200	0	0	1,110	0	0	0	5,310
		PVC	0	0	0	350	0	0	0	350
	100	CI	24,350	650	0	16,650	16,990	0	0	58,640
		PVC	0	0	0	0	800	0	0	800
	125	CI	0	0	800	0	0	0	0	800
	150	CI	14,050	500	150	7,880	4,800	0	0	27,380
		DI	0	0	0	4,300	550	0	0	4,850
		PVC	0	0	0	50	1,850	0	0	1,900
	200	CI	0	450	0	2,850	1,000	0	0	4,300
		PVC	0	0	0	150	0	0	800	950
SUB TOTAL			43,200	1,600	950	32,740	25,990	0	800	105,280
KAWE	50	PVC	0	0	0	850	0	0	0	850
	75	CI	0	0	13,100	0	0	0	0	13,100
		GP	0	0	5,500	1,650	0	150	0	7,300
		PVC	0	0	4,500	25,857	1,200	1,000	3,250	35,807
	100	CI	3,100	0	0	0	0	0	0	3,100
		PVC	0	0	0	13,372	6,100	7,850	0	27,322
	125	PVC	0	0	0	600	0	0	0	600
	150	CI	17,325	0	0	0	75	0	0	17,400
		PVC	0	0	0	13,195	3,600	7,900	1,500	26,195
	200	CI	3,150	0	0	0	0	0	0	3,150
		PVC	0	0	0	5,928	1,350	0	0	7,278
SUB TOTAL			23,575	2,200	23,100	59,252	12,325	16,900	4,750	142,102
KINONDONI	50	CI	350	0	0	0	0	0	0	350
	75	CI	6,500	4,825	3,875	0	0	0	0	15,200
		PVC	0	0	0	4,800	0	0	0	4,800
	100	CI	33,000	26,275	11,475	0	275	0	0	71,025
		DI	0	0	1,550	0	0	0	0	1,550
		PVC	0	0	0	9,550	1,975	0	0	11,525
	125	CI	250	0	1,075	0	0	0	0	1,325
	150	CI	5,275	5,000	3,275	0	550	0	0	14,100
		GP	0	0	400	0	0	0	0	400
		PVC	0	0	1,675	6,475	400	0	0	8,550
	200	CI	2,650	0	3,650	0	0	0	0	6,300
		PVC	0	0	0	975	925	0	0	1,900
SUB TOTAL			48,425	36,100	26,975	21,800	3,725	0	0	137,025
MAGOMENI	50	PVC	0	0	350	0	0	0	0	350
	75	CI	0	0	5,675	0	0	0	0	5,675
		PVC	0	0	3,500	8,480	0	0	0	11,980
	100	CI	0	0	30,300	0	0	0	0	30,300
		PVC	0	0	4,300	8,925	0	0	0	13,225
	150	CI	0	0	7,775	550	225	0	0	8,550
		PVC	0	0	900	2,725	0	0	1,250	4,875
	200	CI	2,550	0	0	0	0	0	0	2,550
SUB TOTAL			2,550	0	52,800	20,680	225	0	1,250	77,505
TEMEKE	75	CI	1,300	0	850	2,650	0	0	0	4,800
		GP	0	0	0	0	0	200	0	200
		PVC	0	0	0	900	1,950	3,600	0	6,450
	100	CI	23,000	50	5,300	31,120	0	550	0	60,020
		PVC	0	0	0	3,850	3,600	6,050	250	13,750
	150	CI	12,300	1,850	3,250	8,100	0	0	0	25,500
		DI	0	0	0	0	50	0	0	50
		PVC	0	0	0	0	0	6,650	0	6,650
	200	CI	1,300	1,850	600	750	0	0	0	4,500
SUB TOTAL			37,900	3,750	10,000	47,370	5,600	17,050	250	121,920
	TOTAL		154,650	41,450	113,825	184,642	48,265	33,950	7,050	583,832

Note : CI cast iron pipe GP galvanized steel pipe PVC poly vinyl chloride pipe DI ductile iron pipe

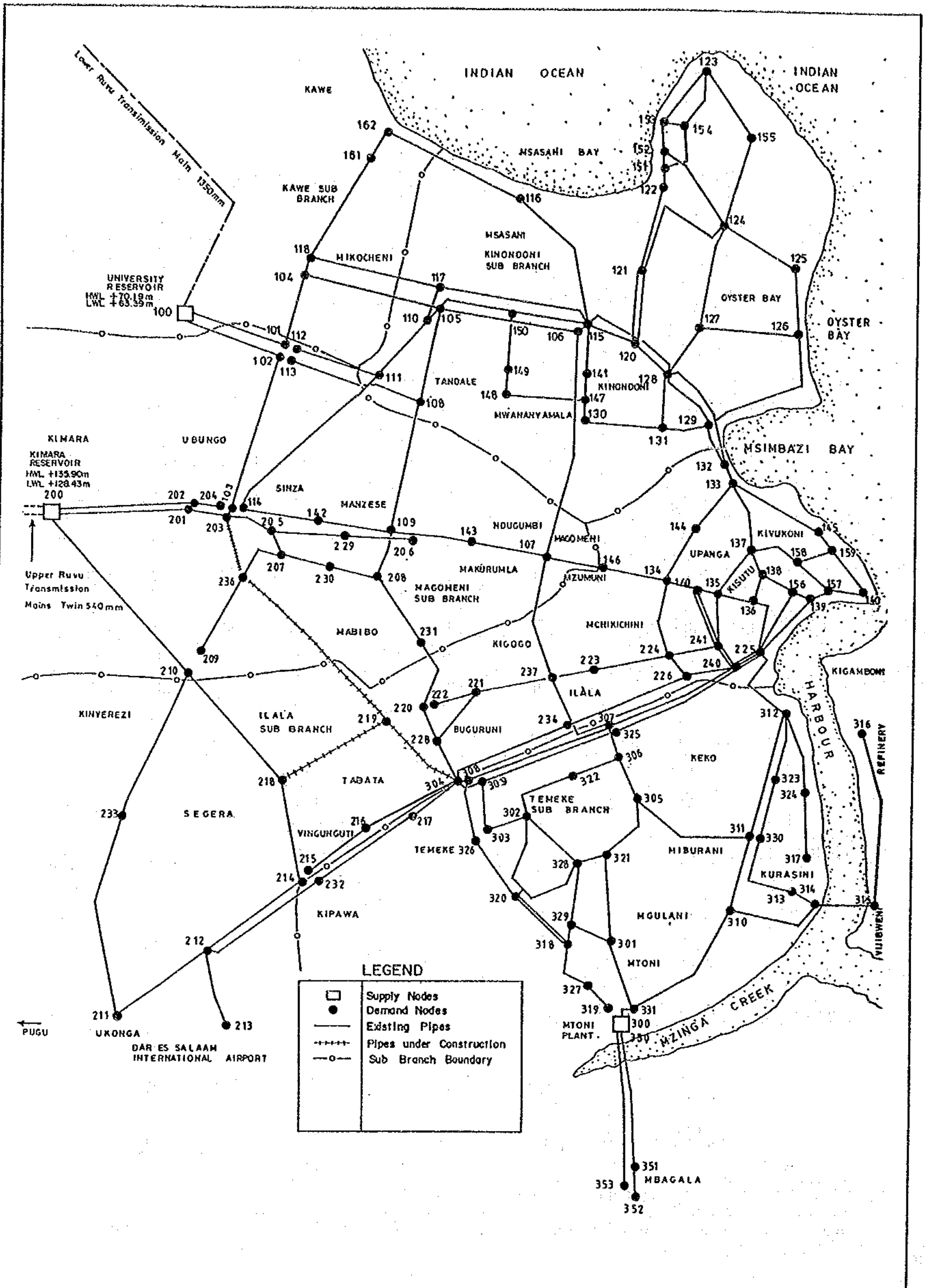


FIG. 4.9 DISTRIBUTION NETWORK

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

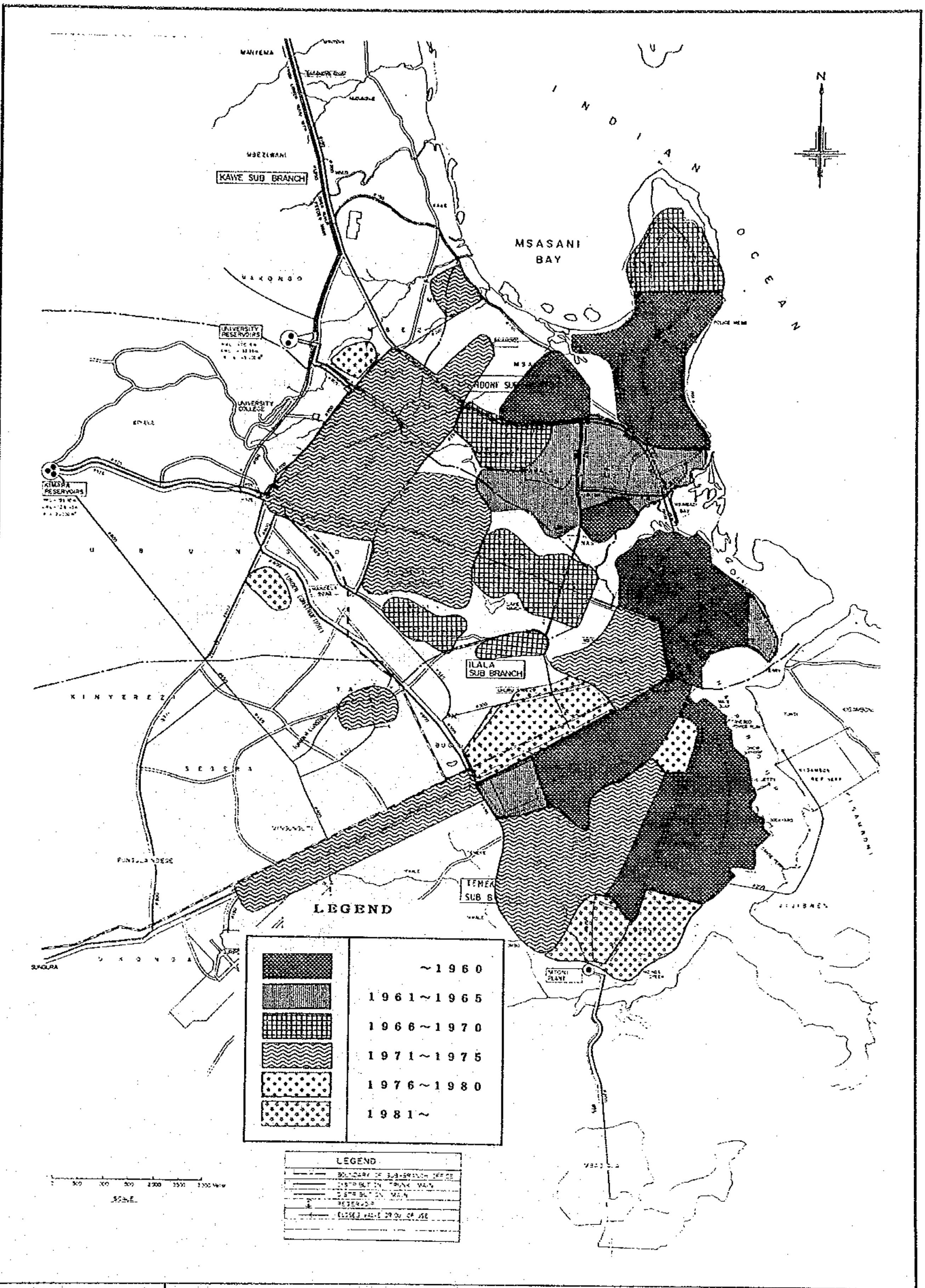


FIG. 4.10	YEAR OF PIPE INSTALLATION

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY

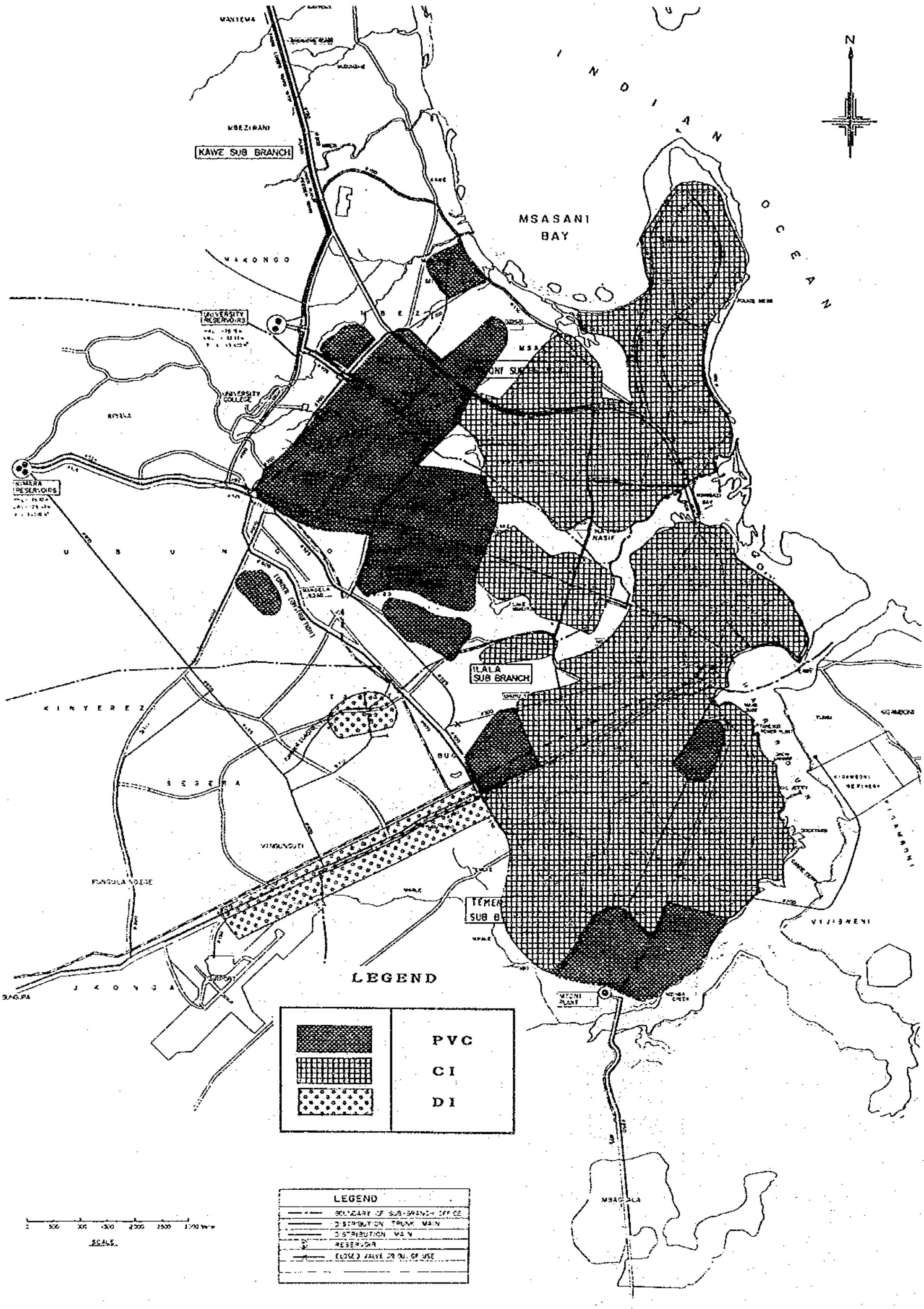
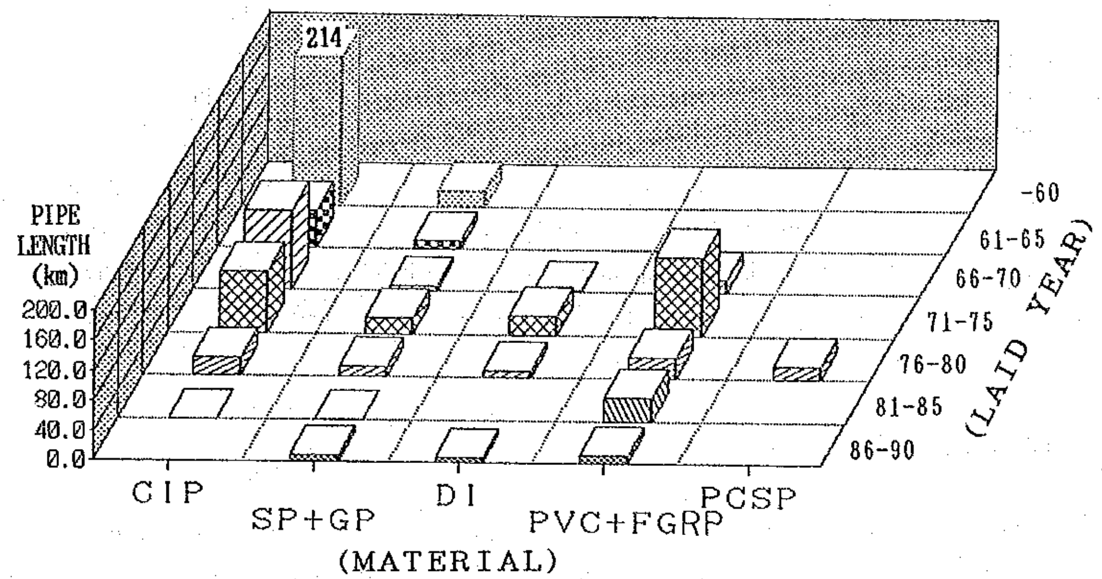
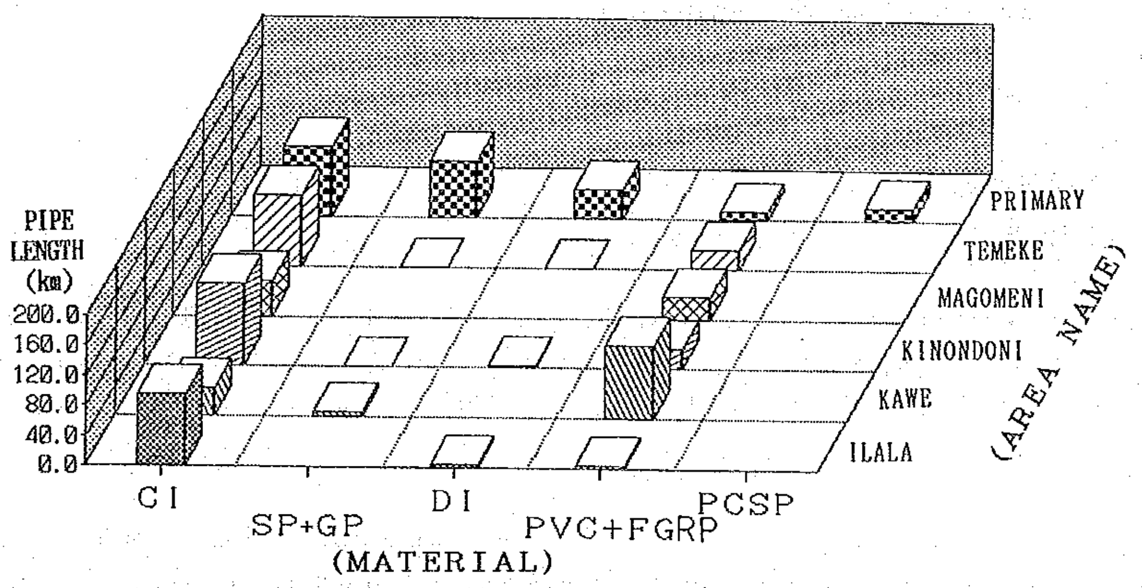


FIG. 4.11	PIPE MATERIAL DISTRIBUTION

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY



DISTRIBUTION PIPE LENGTH BY MATERIAL & LAID YEAR



DISTRIBUTION PIPE LENGTH BY MATERIAL & AREA

FIG. 4.12	DISTRIBUTION PIPE LENGTH CLASSIFIED BY PIPE MATERIAL, YEAR LAID AND AREA

THE STUDY ON REHABILITATION OF DAR ES SALAAM WATER SUPPLY