APPENDIX F

UNACCOUNTED FOR WATER AND PIPELINE SURVEY

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APPENDIX F UNACCOUNTED FOR WATER AND PIPELINE SURVEY

1 INTRODUCTION

The Terms of Reference (TOR) for the present study suggests that :

(a) A survey to assess unaccounted for water (UfW) be undertaken
(b) Assessment of pipelines in the City supply system be completed.

The UfW survey is to be completed in 2-3 townships which are representative of the water supply system in Yangon City. The pipeline assessment will cover the transmission and distribution systems in their entirety.

The aim of Appendix F is to present the procedures as well as the results obtained from the two investigations as mentioned above.

2 UNACCOUNTED FOR WATER SURVEY

After making an assessment of the present situation with respect to UfW in the different townships and in considering the availability of time to plan and complete this survey, the study team decided to undertake the exercise in 3 townships.

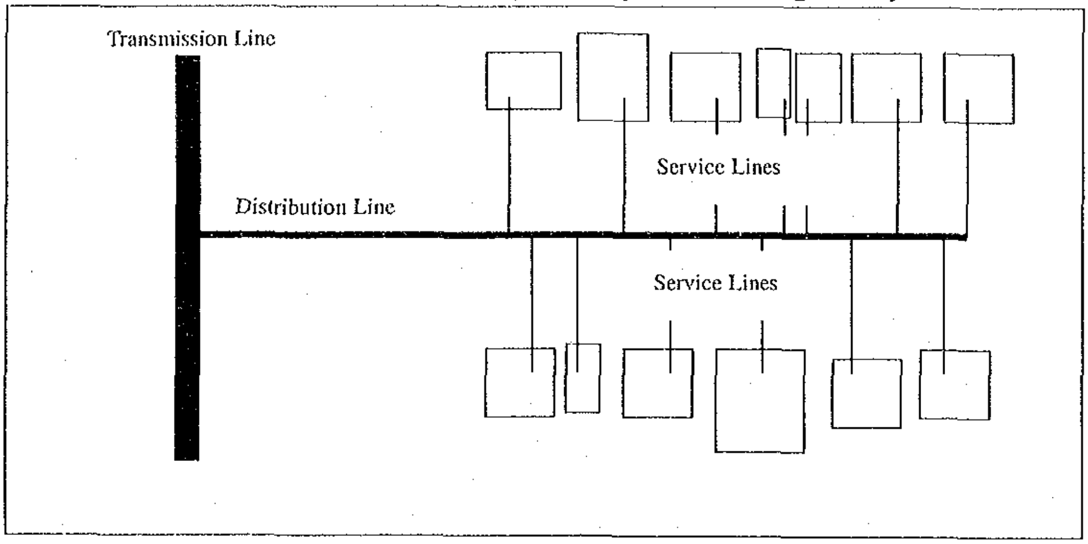
The purpose of this Appendix is to present the methodology for the survey as well as the results of and conclusions from the survey.

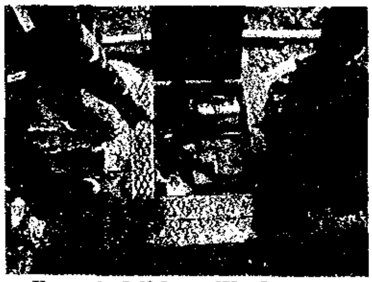
A brief account of the water distribution system in the City is given as a background note.

2.1 LAYOUT OF THE DISTRIBUTION SYSTEM

The pipeline network in the City comprising of transmission mains, distribution pipes and service lines can be considered as a simple system (Figure F.1). In this network, the distribution lines branch off from washout and air valve in the transmission main pipe (Photo F.1). In general, each distribution line eventually supplies water to several service lines on the downstream of the system. The service lines provide water to customers either to individual households via a pipe in the house/compound or to groups of customers via a communal tank.

Figure F.1 Sketch of Pipeline System in Yangon City




Branch Off from Wash Out


Branch Off from Air Valve

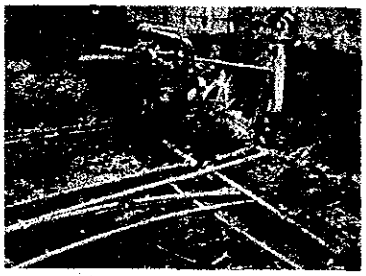

Branch Off from Air Valve

Photo F.1 Branching Off Distribution Lines from Transmission Mains

The study team observed what is called as "spaghetti service pipes" in some areas of the system in that that several service pipelines exposed on the ground are laid in parallel to each other (extreme right photo in Photo F.1). Furthermore, leakage survey group in JICA study team found that there is small in number of valve installed in Yangon.

2.2 THE METHODOLOGY

2.2.1 Selection of Model Blocks

In accordance with the TOR for the study, the first task was to identify 2-3 townships which are representative of the distribution system. The study team employed two criteria to select the model blocks as listed below:

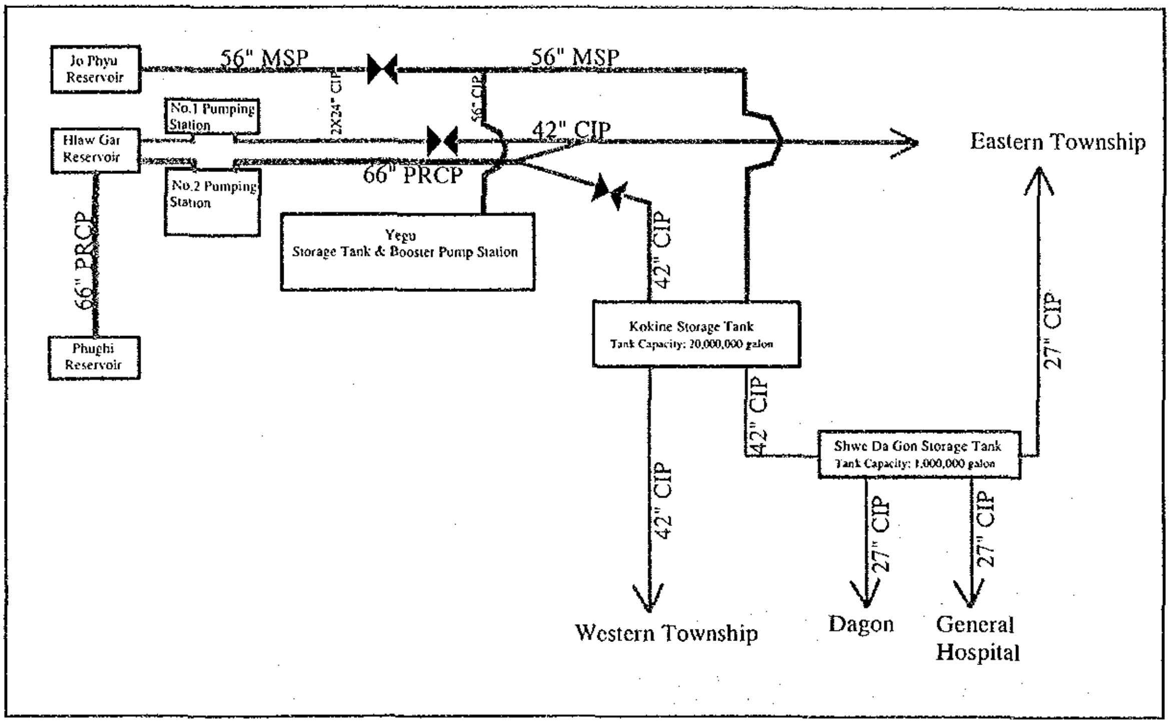
- Area of a township receiving water for 24 hours
- Area of a township where water pressure is high

The manner by which the above criteria was assessed is explained below.

(1) Area receiving 24-hour water supply

The starting point for this investigation was to establish the flow of transmission mains in the City (Figure F.2).

Figure F.2 The Flow of the Transmission Line



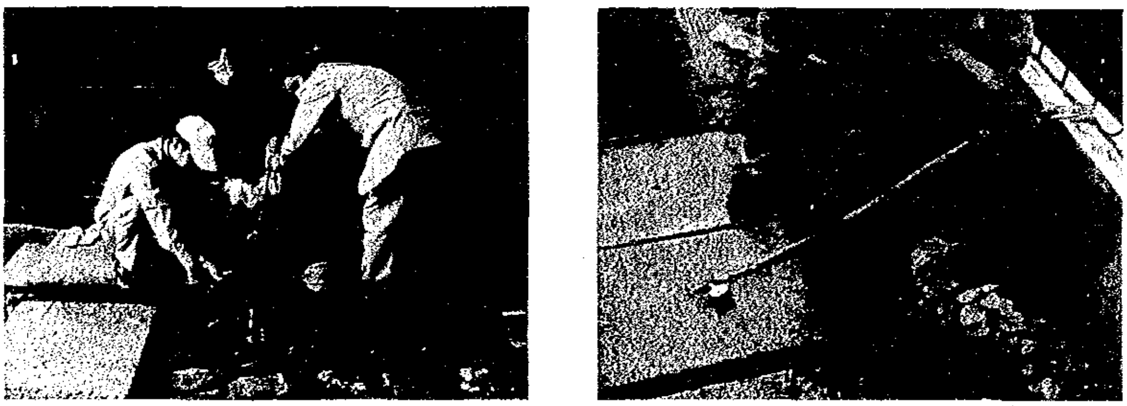


Photo F.2 Water Pressure Measurement

Accordingly, two areas (in townships of Bahan and Yankin) where the water pressure was high were selected.

Areas from the down town were not selected as a model block due to the following reasons:

- The down town area does not receive 24 hours of supply
- The system's pressure is low in the area
- The lack of detailed information on the pipeline system in this area
- Difficulty that would be encountered in undertaking the investigation due to higher volume of traffic in this area.

(2) Characteristics of four selected model blocks

Given below are the characteristics of the four model blocks selected for detailed investigations.

a. Insein township

- This model block is located in the northern suburbs of Yangon. It is a lower-middle class residential area.
- Nearly 100% of consumer in this model block have paid water bills by meter reading.
- Water is being supplied to this model block via a pipeline which branches off 66-inch transmission line.
- The distribution pipelines in this model block are GIP laid 3 years ago.

b. Yankin township

- This model block is located in the center of Yangon, and it represents a middle class residential area.
- Distribution pipeline which supplies water to this model block branches off the 42-inch transmission line.
- The material of the distribution pipelines in this model block is CIP laid 30 years ago.

c. Bahan Township

- This model block is also located in the center of Yangon near the Kokine reservoir.
- The water users consist of a mixture of commercial and the upper-middle class customers.
- Water supply pipeline to this block branches off an 42 inches of transmission line from Kokine reservoir.
- The pipelines in this model block are made up of CIP laid out presumably some 50 years ago.

d. Tamwe Township

- This model block is also located in the center of Yangon. The area consists of apartment houses along the street. It represents a lower-middle class residential area.
- The distribution pipeline branches off the 42-inch transmission line.
- The pipelines in this model block are made up of CIP laid out some 70 years ago.
- The southern border of this model block experiences water supply limitations.

Location map of each model block are shown in the Figure F.3.

After conducting the investigations in Bahan township, the network in this area was found to be in operation in a complicated manner. The officers in-charge of operations in these areas could not supply correct and reliable information in order to explain the abnormal behaviour of the flow distribution. Hence, the results from the investigation in this model block do not show the actual data pertaining to UfW.

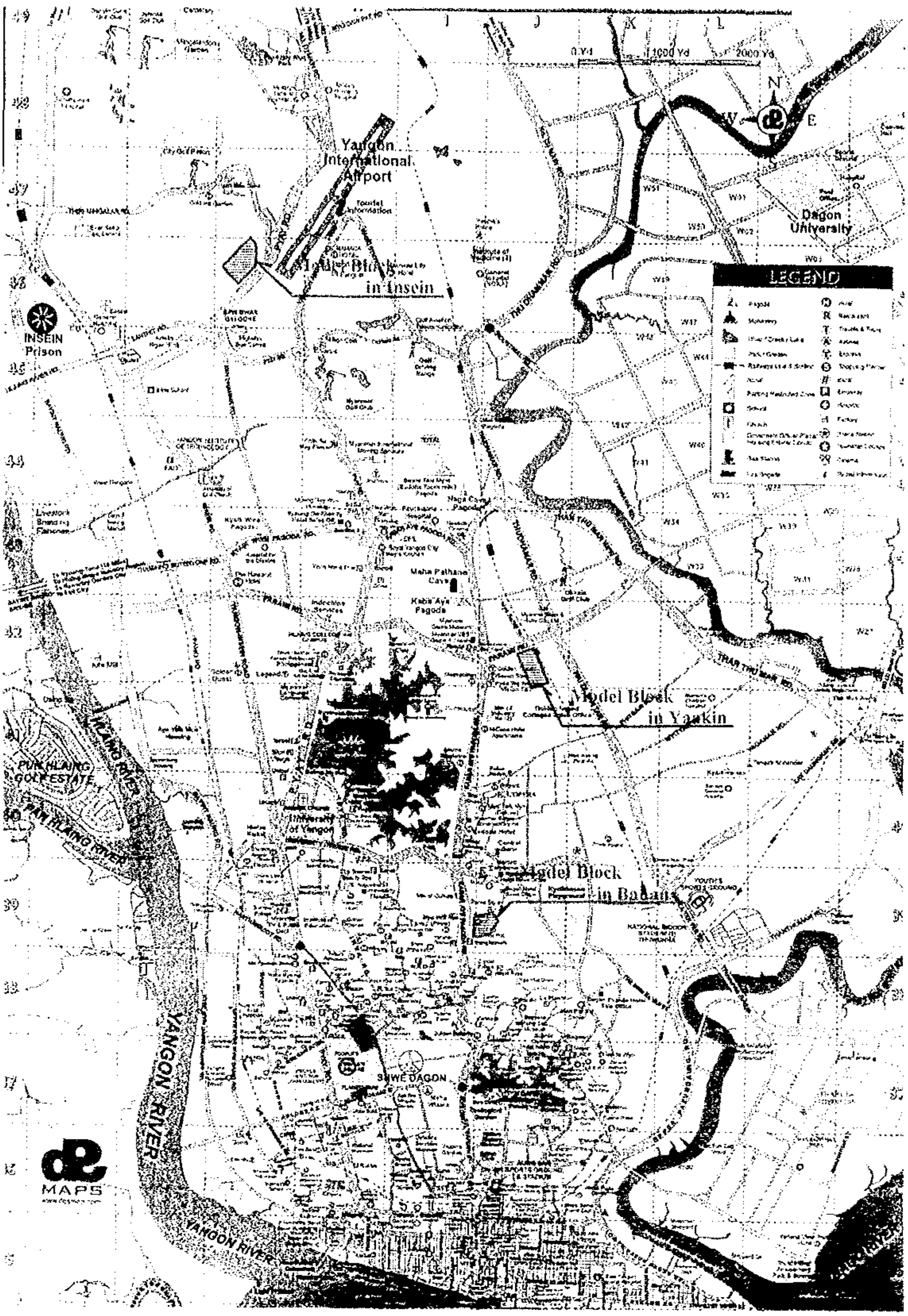


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FIG. F.3

The Location of Model Blocks

2.2.2 Preparation Work for Measurement

First, the consumer lists in the selected model blocks were prepared (Tables F.1) whereas the detailed maps of model blocks are found in Figures F.4.

New domestic meters were installed by YCDC staff for those customers without a meter (ie. flat rate customers and free customers such as monastery). Similarly, the defective meters were removed and new domestic meters were installed by YCDC staff. (Photo F.3).

Photo F.3 Installation of New Domestic Meters

To measure the accurate inlet volume, a part of existing pipe at the measurement point was replaced with a new pipe as shown in the photo below.

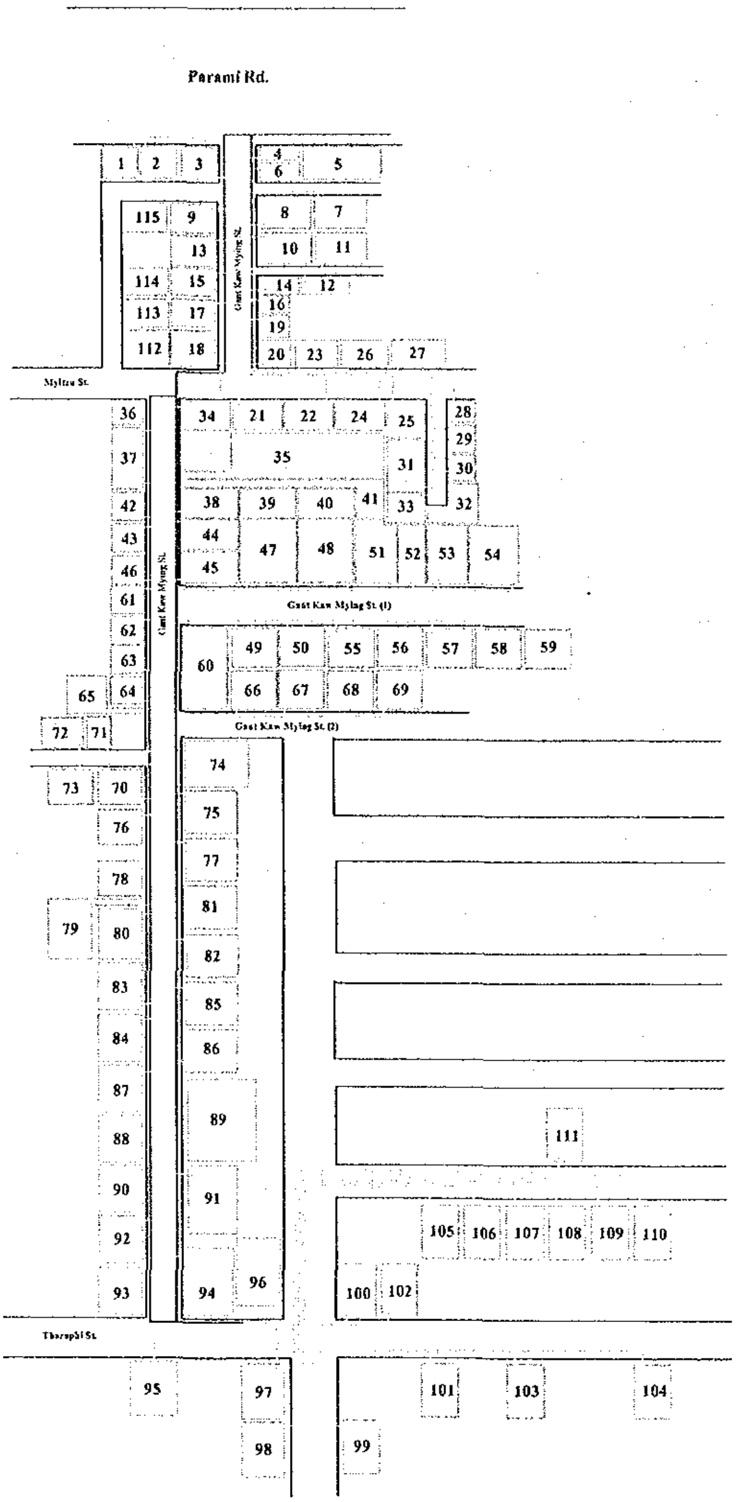
Photo F.4 Replacing Part of Existing Pipeline with a New Line

Table F.1 Consumer List of Model Block in Yankin

No.	Household Name	Address	No. of Family	Extence of Water Meter	Water Meter Condition	Pipe Diameter	Registered Meter No.	March	April	May	Last Indicated Value by Meter Reader
1	U Than Aung	No.60 Parami. 8.Ward	5	Yes	Good	1"	960683	55	255	87	3222
2	U Myo Myint	No.58 Parami. 8. Ward	7	"	"	1"	70844	106	120	100	5308
3	U Sein	No.66 Parami. 8. Ward	5	"	"	1"	960704	70	105	59	4857
4	U Win Lwin	No.68 Parami. 8. Ward	5	"	"	1"	70761	52	100	110	3895
5	Daw Khin Nyein	No.54-B Parami. 8. Ward	6	"	Defective	1"	7073	81	100	60	AVERAGE
6	U Win Lwin	No.68-B Gant Kaw Mying. 8. Ward	5	"	Good	1"	70029	78	30	110	829
7	Daw Khin Aye Kyu	No.1 Gant Kaw Myint 8-Ward	7	"	"	1"	963754	67	95	59	4287
8	U Myo Min Htun	No.1-A Gant Kaw Mying .8-Ward	3	"	"	1"	964225	99	91	97	4973
9	Daw Khin Than	No.2 Gant Kaw Mying .8-Ward	3	"	"	1"	964251	98	109	105	4536
10	U Ohn Kyaw	3.A Gant Kaw Mying .8-Ward	3	"	"	1"	70973	42	62	65	6079
11	U Kyaw Oo	3.B Gant Kaw Mying .8-Ward	5	"	"	1"	961658	85	30	33	4030
12	U Soe Than	No.3.C Gant Kaw Mying .8-Ward	5	"	"	1 1/4"	70876	57	15	20	1480
14	U Htoo Hling	No.5 Gant Kaw Mying .8-Ward	6	"	"	1"	963588	2	70	75	5574
15	Daw Yin Kyi	No.6 Gant Kaw Mying .8-Ward	2	"	Defective	3/4"	963990	20	40	10	1344
16	Daw Shu Yin	No7 Gant Kaw Mying .8-Ward	12		Good	1"	960758				
17	U Soe Win	No.8 Gant Kaw Mying .8-Ward	6	"	"	1"	960395	66	78	69	2111
18	U Han Htwe	No.10 Gant Kaw Mying .8-Ward	2	"	"	1"	962766	70	31	30	1279
20	U Khin Thein	No.11 Gant Kaw Mying 8-Ward	4	"	"	1"	70896	31	35	37	3204
21	Daw Pyone Thwzn	No.1 Myitzu Lane 2.8-Ward	6	"	"	1"	961735	55	48	112	2412
22	Daw Wai Wai	No.1.B Myitzu Lane 2.8-Ward	8	"	"	1"	963885	125	193	120	5993
23	U Ko Ko Gyi	No.12 Myitzu Lane 2.8-Ward	6	"	"	1"	70815	25	20	20	2109
24	Dr.Tin Aung	2.D Myitzu Lane 2.8-Ward	7	"	"	1"	70928	30	35	30	181
25	Daw Thein Thein Yi	2.D Myitzu Lane 2.8-Ward	10	"	Defective	1"	50932	105	90	100	5334
26	U Thaung Tin	2.D Myitzu Lane 2.8-Ward	13	"	"	1"	70990	85	50	50	636
27	Daw Saw Kyi	2.D Myitzu Lane 2.8-Ward	3	"	"	1"	70958	55	35	40	279
28	U Soe Tint	2.D Myitzu Lane 2.8-Ward	3		"	1"	14306				
29	Daw Aye Aye Thin	2.D Myitzu Lane 2.8-Ward	15		Construct	1"	20385				
30	U Soe Thein	2.D Myitzu Lane 2.8-Ward	2		Defective	1"	50726				
32	U Than Aung	2.D Myitzu Lane 2.8-Ward	2		"	1"	50923				
33	U Myint Than	2.D Myitzu Lane 2.8-Ward	5		"	1"	20305				
34	U Khon Naung	No.90 Myitzu Lane.2. 8-Ward	6	"	Good	1"	961198	95	64	74	2294
35	Daw Pyone Thwin	No.90 Myitzu Lane.2. 8-Ward	3			1"	50843				
37	Daw Kyi	No.19 Gant Kaw Mying 8-Ward	2	"	"	1"	962735	30	69	22	961
37	U Sein Hla	No.19 Gant Kaw Mying 8-Ward	3	"	"	1"	962038	29	29	30	1872
38	U Kyaw One	No.36-G Gant Kaw Mying 8-Ward	4	"	"	3/4"	961317	28	30	10	1592
39	U Than Htun	No.36-G Gant Kaw Mying 8-Ward	4	"	"	1"	964732	36	34	31	1516
40	U Htun Soe	No.36-E Gant Kaw Mying 8-Ward	4	"	"	1"	960550	30	35	26	1005
41	Daw Khin Saw New	No.36-E Gant Kaw Mying 8-Ward	5	"	Defective	1"	70622	35	32	25	858
42	U Mg Mg Aye	No.26 Gant Kaw Mying 8-Ward	3	"	"	3/4"	960084	49	65	30	2103
43	U Tin Win	No.98 Gant Kaw Mying 8-Ward	7	"	"	1"	961386	62	79	50	6318
45	U Kyaw Thein	No.36-C Gant Kaw Mying 8-Ward	4	"	"	1"	962839	54	38	55	4022
46	U That Htun	No.98-B Gant Kaw Mying 8-Ward	5	"	"	1"	961544	55	86	45	2776
47	Daw Khin May Si	No.36-B Gant Kaw Mying 8-Ward	8	"	"	1 1/4"	70963	40	52	45	4810
48	U Shwe Than	No.36 Gant Kaw Mying 8-Ward	5	"	"	1 1/4"	70755	63	61	61	2505
49	U Zay Ya	No.1 Gant Kaw Mying 8-Ward	6	"	"	1"	960466	35	50	50	3253
50	Daw Khin Khin Sein	No.2 Gant Kaw Mying 8-Ward		"	"	1"	963330	2	5	55	589
51	U San Thar	No.36 Gant Kaw Mying 8-Ward	6	"	"	1"	70822	35	30	35	6629
52	U Win Thar Htay	No.36 Gant Kaw Mying 8-Ward	5	"	"	1"	70766	10	20	20	1169
55	U Aung Ngwe	No.3 Gant Kaw Mying 8-Ward	4	"	"	1"	963158	20	22	20	948
57	Daw Khing Khing Cho	No.5 Gant Kaw Mying 8-Ward	3	"	"	1"	963505	35	35	35	6830
59	Daw Nu Nu Sein	No.7Gant Kaw Mying 8-Ward	4	"	"	1"	20306	60	35	35	2147
61	Daw Tin Hla	No.101 Gant Kaw Mying 8-Ward	3	"	"	1 1/4"	960265	82	91	57	1619
63	Daw Aye Kway	No.100 Gant Kaw Mying 8-Ward	6	"	"	1"	96031	55	40	35	759
64	U Paw Htun	No.104 Gant Kaw Mying 8-Ward	4	"	"	1"	70802	48	36	50	1190
65	U Myint Thein	No.130 Gant Kaw Mying 8-Ward	4			1"	9.91E+08				
66	Daw Khin Cho New	No.15Gant Kaw Mying 8-Ward	5	"	"	1"	962710	90	145	66	3475

Table F.1 Consumer List of Model Block in Yankin

No.	Household Name	Address	No. of Family	Existence of Water Meter	Water Meter Condition	Pipe Diameter	Registered Meter No.	March	April	May	Last Indicated Value by Meter Reader
67	U Kyaw Kyaw Win	No.14 Gant Kaw Mying 8-Ward	2	"	"	1"	70771	75	40	25	1493
68	U Khin Mg Cho	No.13 Gant Kaw Mying 8-Ward	2	"	"	1"	960926	30	34	26	1493
69	Daw Khin Soe Win	No.10 Gant Kaw Mying 8-Ward	3	"	"	1"	50987	70	31	30	1279
70	Dr. Soe Min	No.111 Gant Kaw Mying 8-Ward	5	"	"	1"	2373	65	53	34	589
71	U Than Mg	No.101 Gant Kaw Mying 8-Ward	11	"	"	1"	9.91E+08	60	80	50	1399
72	Daw Khin Khin Thein	No.101 Gant Kaw Mying 8-Ward	5	"	"	1"	7423	82	91	57	1619
73	U Zaw Win	No.101 Gant Kaw Mying 8-Ward	3	"	"	1"	10669	35	35	33	1965
74	U Thar Htun Aung	No.111 Gant Kaw Mying 8-Ward	7	"	"	1"	12618	55	61	61	649
75	U Hla Than	No.297 Gant Kaw Mying 8-Ward	7	"	"	1"	964557	40	30	35	4289
76	Daw Tin Kyi	No.167 Gant Kaw Mying 8-Ward	10	"	"	1"	962467	100	135	76	462
77	U Moe Kyaw Shwe	No.68 Gant Kaw Mying	4	"	"	1"	70011	120	120	100	9041
79	U Min Zaw	No.68 Gant Kaw Mying	5	"	"	1"	9144	54	91	46	622
80	U Htun Aung	No.145 Gant Kaw Mying	5	"	"	1"	963281	300	92	111	4451
82	U Ba Htay	No.175 Gant Kaw Mying	6	"	"		961686	20	36	28	2014
83	Daw Aye Nu	No.174.A Gant Kaw Mying	5	"	"		962540	82	117	89	2666
84	U Thein Win	No.98 Gant Kaw Mying	6	"	"		962330	60	80	55	3096
85	U Khin Mg Lwin	No.99.B Gant Kaw Mying	5	"	"		964876	200	289	100	5937
87	U Sein Win	No.99Gant Kaw Mying	7	"	Defective		70724	40	45	35	VERAGI
91	U Khon Phone	No.89Gant Kaw Mying	2	"	"		96105579	25	30	5	402
92	U Tun Shwe	No.629 Gant Kaw Mying	2	"	"		4334	40	30	35	4289
94	U Kyin Shein	No.86 Gant Kaw Mying	10	"	"		963200	45	58	43	2293
95	U Myint Htay	No.100 Gant Kaw Mying	10	"	"		5007	40	40	45	2328
96	U Than Ngae	No.68 Gant Kaw Mying	5	"	"		97120876	20	22	18	774
97	U Win Thein	No.15 Gant Kaw Mying	5	"	"		70900	35	35	50	1606
99	U Kyaw Min	No.78Gant Kaw Mying	3	"	"		963189				
100	U Tun Aung	No.73 Gant Kaw Mying	4	"	"		961900	56	30	88	2191
101	Daw Khin Mar Thin	No.66 Gant Kaw Mying	5	"	"		6841	65	50	117	423
102	U Ni	No.66 Gant Kaw Mying	9	"	"		7563	35	28	40	986
103	Daw Ohmar	No.15 Gant Kaw Mying	5	"	Defective		50954	50	50	40	4639
104	U Thein Aung	No.679 Gant Kaw Mying	9	"	Good		12833		126	89	215
105	U Thaung Shwe	No.47 Gant Kaw Mying	4	"	"		9123	128	100	100	1595
106	U Khon Phone	No.48 Gant Kaw Mying	4	"	"		70593	39	40	35	583
107	U Than Htun	No.267 Gant Kaw Mying	5	"	"		961366	60	30	33	3389
108	U Lin Shein	No.267 Gant Kaw Mying	4	"	"		960980	88	50	50	3395
109	U Mya Wai	No.267 Gant Kaw Mying	6	"	"		962883	38	30	70	3160
110	U Sein Phe	No.267 Gant Kaw Mying	6	"	"	1"	960128	52	35	40	2272
111	Daw Yin Yin San	No.267 Gant Kaw Mying	4			1"	14739				
112	U Nay Min	No.8 Tha Zin Mying -8-Ward	7	"	"	1"	960981	120	50	80	2873
112	Daw Win Han	168-B Myitzu lane	2				963012				
113	Daw Khin May Than	No.6 Tha Zin Mying -8-Ward	5	"	"	1"	964170	97	35	50	3078
114	Daw Ni Ni Tin	No.4 Tha Zin Mying -8-Ward	8	"	"	1"	960027				
115	U Nay Htun	No.2 Tha Zin Mying -8-Ward	5	"	"	1"	9630328	50	43	35	215
116	Daw Khin Moe Moe	No.116 Thariphi	4			3/4"	964378				
117	Daw Soe Win	42.D Thariphi	4			3/4"	7428				
118	U Aung Phay	42 Thariphi	5			3/4"	74366				
119	Daw Mya Gyi	674 Thariphi	5			3/4"	4328				
120	U Mya	115 Thariphi				3/4"	4429				
121	U Mg Mg Htun	670 Thariphi	10			3/4"	4306				
122	U Htay	97 Thariphi	4			3/4"	7342				
123	Monastry(1)						50927				
124	Monastry(2)						50300				
125	School										
126	Monastry(3)						50317				
	U Win Tin	( ) Myitzu Lane					50970				
	Monastry	1 Hantkaw Myay 8-Ward					20350				



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The Detailed Map of The Model Block in Yankin

Figure F.4

2.2.3 The Measurements

(1) The model block in Insein

During the period from July 10th to July 13th, an ultrasonic flow-meter was installed by the study team (Photo F.5). The inflow volume into the block was measured continuously for a period of 72 hours.

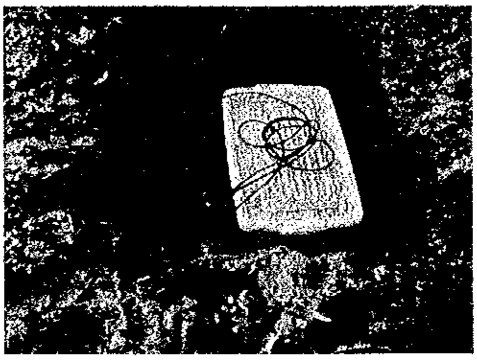


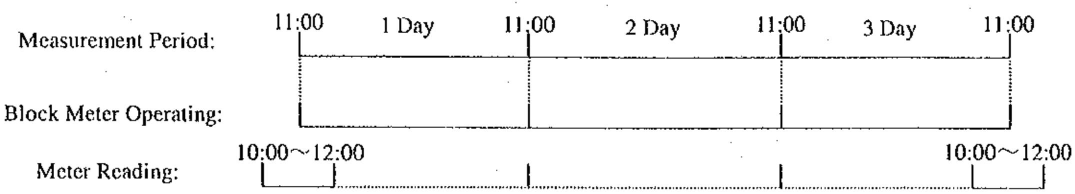
Photo F.5 Installation of Ultrasonic Meter

In addition, the study team read all domestic meters in the model blocks both at the beginning and end in order to measure the amount of water consumed for three days (Photo F.6).

Photo F.6 Meter Reading for the Survey by YCDC Staff

Figure F.5 shows the relationship between block meter and domestic meter reading during the measurement period.

FIGURE F.5 The Relationship between the Block Meter and the Domestic Meter Readings



(2) The model block in Yankin

During the period from July 24th to July 27th, an ultrasonic flowmeter was installed at the inlet point to the model block by the study team (Photo F.7). Accordingly, the inflow volume into the block was measured continuously for a period of 72 hours.

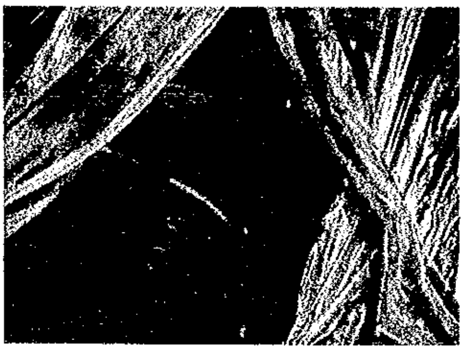


Photo F.7 Installation of Ultrasonic Meter

Following the same procedure as in the model block in Insein, the study team read all domestic meters at the beginning and end in order to measure the amount of water consumed for three days (Photo F.8).

Photo F.8 Meter Reading for the Survey by YCDC Staff

(3) The model block in Bahan

During the period from August 8th to August 10th, an ultrasonic flowmeter was installed at the inlet point of the model block by the study team (Photo F.9). The inflow volume into the block was measured continuously for a period of 48 hours.

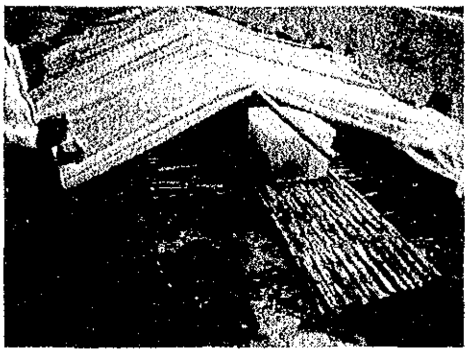


Photo F.9 Installation of Ultrasonic Meter in Bahan Township

Following a procedure similar to earlier model blocks, the study team read all of the domestic meters in the block at the beginning and end. The actual amount of water consumed for two days was calculated.

(4) The model block in Tamwe

The ultrasonic flow meter measured the flow for the period from August 8th to August 10th (Photo F.10). The inflow volume into the block was measured continuously for a period of 72 hours.

Photo F.10 Installation of Ultrasonic Meter in Bahan Township

The same procedure as in other model blocks was followed to calculate the amount of water consumed for two days.

2.3 RESULTS

2.3.1 The model block in Insein

The following conclusions are reached from the measurements obtained in Insein.

(a) According to the logging data of ultrasonic flowmeter, 716m3 of water (a) were distributed into the model block area for three days. The inlet flow data is shown in Table F.2. The inlet flow chart during the measurement is shown in Figure F.6.

(b) According to meter reading data for three days (Table F.6) for the model block in Insein, 565m3 (b) of water were consumed. This works out to an average water consumption of 1.38m3 per household in the model block in Insein.

(c) There are no illegal connections or public taps in this block. Therefore, 151m3 (21%) (c) is considered to be the UfW.

(d) From the characteristic of this model block, due to the grasping of the leakage volume, minimum night flow method was adopted as shown in Figure F.7. According to the data of minimum night flow, the leakage volume in this block was 94.95m3 (13.3%) (d) for three days.

(e) Leakage survey group in JICA study team was re-investigated in the model block in Insein for 56.05m3 which is the balance of (c) - (d). Besides, 23 of households and the property were found as the result. The details are shown in the following.
   - 18 out of 23 are households using water only at night.
   - 4 out of 23 are the property which the domestic meter and tap exist. Therefore, someone is using water.
   - 1 out of 23 is monastery.

(f) Most households in this model block are using rainwater during the rainy season. The per capita consumption is quite high for seven out of 136 households.

No.	Household Name	Address	No. of Family	Meter Reading on 10th of July	Meter Reading on 13th of July	Balance	Consumption per capita
12	U Htay Lwin	No.37 Tha Zin St, Htan Pin Gon Ward	3	756	767	11	1.22
42	U Kyi Win	No.6-C Hnin Se St, Htan Pin Gon Ward	5	1768	1789	21	1.40
54	U Nan Da Hlaing	No.61 Myint Su St, Htan Pin Gon Ward	3	2661	2685	24	2.67
63	U Bo Than	No.152 Aung Thit Sar ,Pi Taut Myein	6	1707	1733	26	1.44
70	Daw Ou	A-125 Aung Thit Sar ,Pi Taut Myein	3	1750	1762	12	1.33
76	U Aung Min	No.883 Aung Myitter, Pi Taut Myein	1	1056	1059	3	1.00
94	U Khin Mg Zaw	No.34 Sa Pe St, Htan Pin Gon	2	118	126	8	1.33

(g) 5 leaks were detected (where?; customer or distribution lines?).

Table F.2 The Inlet Flow Data of The Model Block in Insein

Date	Time	Flow (m3/min)	Total (m3)
July 10th	11:00	0.23	0
	12:00	0.24	15.21
	13:00	0.12	26.73
	14:00	0.31	39.85
	15:00	0.13	54.36
	16:00	0.32	69.27
	17:00	0.31	88.52
	18:00	0.21	105.27
	19:00	0.25	122.61
	20:00	0.16	134.49
	21:00	0.20	144.82
	22:00	0.14	154.37
	23:00	0.05	157.96
July 11th	0:00	0.04	160.75
	1:00	0.04	163.37
	2:00	0.04	166.14
	3:00	0.04	168.61
	4:00	0.08	171.7
	5:00	0.04	175.34
	6:00	0.20	181.05
	7:00	0.26	194.83
	8:00	0.26	207.89
	9:00	0.32	225.78
	10:00	0.18	238.46
	11:00	0.25	252.24
	12:00	0.19	263.29
	13:00	0.14	275.23
	14:00	0.18	286.31
	15:00	0.18	297.89
	16:00	0.18	310.92
	17:00	0.22	326.46
	18:00	0.20	343.34
	19:00	0.23	356.46
	20:00	0.18	368.01
	21:00	0.14	377.98
	22:00	0.08	386.15
	23:00	0.06	390.37

Date	Time	Flow (m3/min)	Total (m3)
July 12th	0:00	0.06	394.89
	1:00	0.07	398.55
	2:00	0.06	402.22
	3:00	0.06	405.63
	4:00	0.06	409.12
	5:00	0.06	412.72
	6:00	0.15	418.99
	7:00	0.21	432.16
	8:00	0.25	446.89
	9:00	0.19	459.24
	10:00	0.19	472.89
	11:00	0.18	486.16
	12:00	0.25	499.42
	13:00	0.34	513.57
	14:00	0.25	527.58
	15:00	0.24	543.59
	16:00	0.21	556.21
	17:00	0.34	573.2
	18:00	0.34	591.63
	19:00	0.26	608.38
	20:00	0.21	620.76
	21:00	0.12	629.36
	22:00	0.06	633.16
	23:00	0.04	635.46
July 13th	0:00	0.03	637.67
	1:00	0.04	639.44
	2:00	0.02	641.18
	3:00	0.04	642.98
	4:00	0.02	644.81
	5:00	0.05	646.57
	6:00	0.21	652.78
	7:00	0.22	665.49
	8:00	0.19	679.49
	9:00	0.26	692.99
	10:00	0.20	706.37
	11:00	0.15	716.87

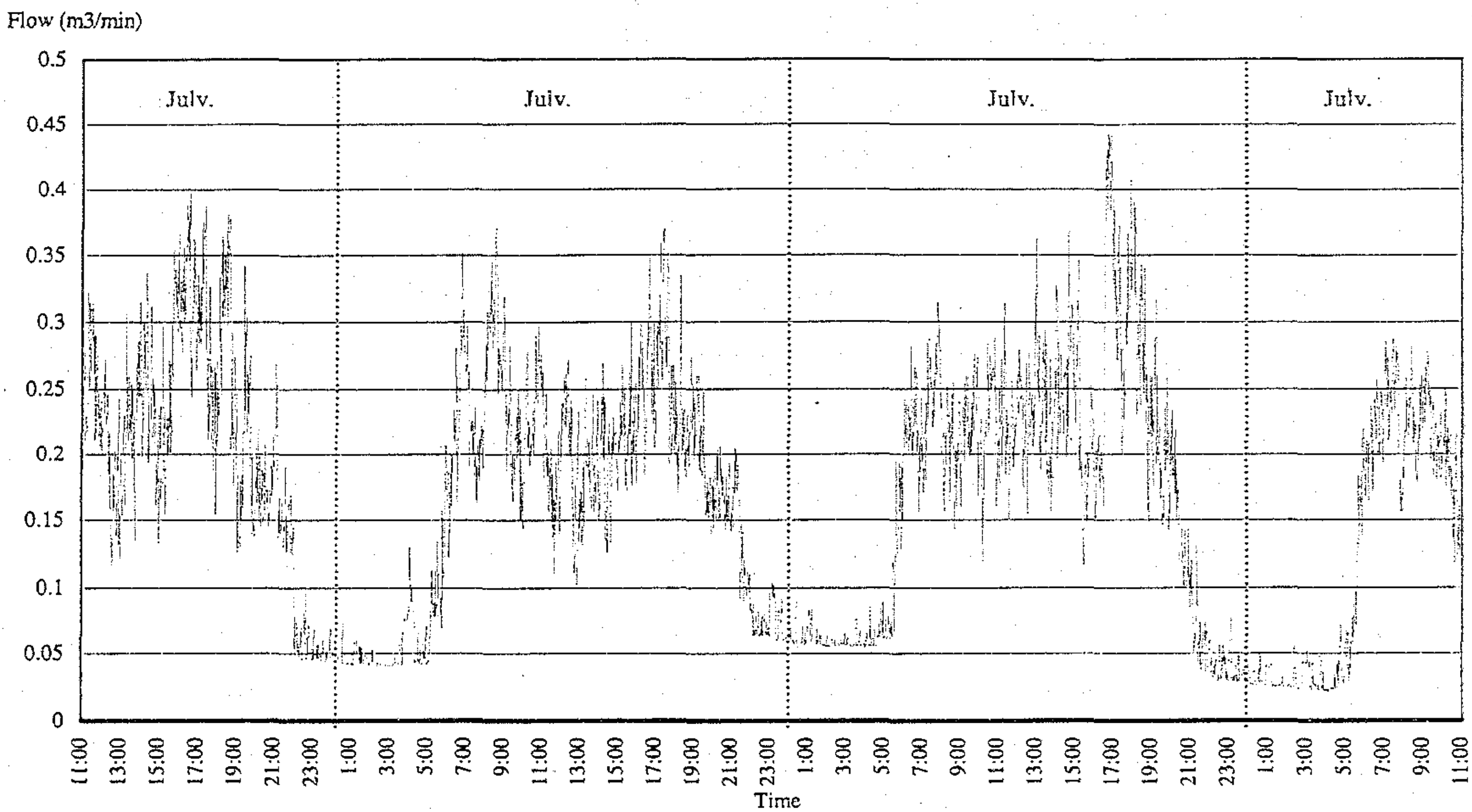


Figure F.6 The Chart of Inlet Flow in Insein

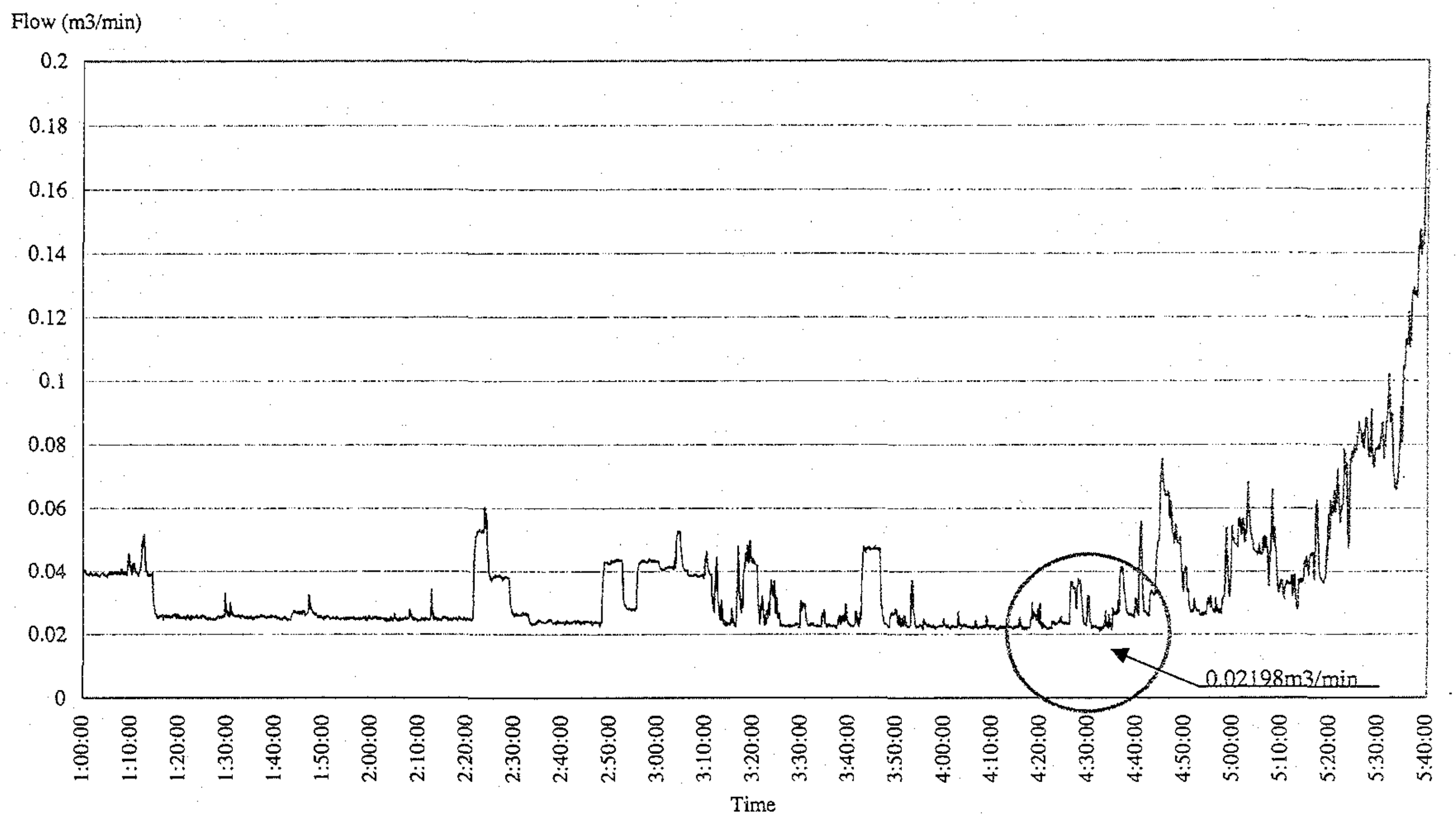


Figure F.7 Minium Night Flow (July, 13)

2.3.2 The model block in Yankin

The following conclusions are derived from the results of model block in Yankin.

(a) According to the logging data of ultrasonic flowmeter, 1698m3 (a) of water were distributed into the model block for three days. The inlet flow data is shown in Table F.3. The inlet flow chart during the measurement is shown in Figure F.13.

(b) According to meter reading records (Table F.4), 700m3 of water (b) were consumed in the model block in Yankin for three days. This works out to an average consumption of 2.1m3 per household in the model block in Yankin.

(c) No illegal connections or public taps were observed in this block. Therefore, 998m3 (58.8%) (a) – (b) is considered as the leakage volume for three days (Figure F.8). This amount is equivalent to 231 liters per minute.

(d) 10 leaks were detected (where ?...).

Table F.3 The Inlet Flow Data of The Model Block in Yankin

Date	Time	Flow (m3/min)	Total (m3)
July 24th	11:00	0.36789	0
	12:00	0.39676	23.96
	13:00	0.36167	46.76
	14:00	0.42876	71.68
	15:00	0.35265	94.23
	16:00	0.38019	116.86
	17:00	0.45658	141.07
	18:00	0.47736	172.56
	19:00	0.44217	201.14
	20:00	0.42696	228.65
	21:00	0.35573	251.36
	22:00	0.33302	271.6
	23:00	0.32396	291.9
July 25th	0:00	0.29269	310.33
	1:00	0.29793	327.93
	2:00	0.29766	345.53
	3:00	0.29551	362.82
	4:00	0.29925	381.17
	5:00	0.30759	399.72
	6:00	0.44625	420.61
	7:00	0.54996	451.71
	8:00	0.42504	480.14
	9:00	0.47957	507.37
	10:00	0.41014	532.89
	11:00	0.44539	557.57
	12:00	0.43177	582.74
	13:00	0.45646	608.23
	14:00	0.44257	635.96
	15:00	0.44468	662.79
	16:00	0.52745	690.4
	17:00	0.4537	719.65
	18:00	0.49487	749.6
	19:00	0.49578	778.85
	20:00	0.47476	808.66
	21:00	0.41941	834.6
	22:00	0.33742	858.48
	23:00	0.35217	877.97

Date	Time	Flow (m3/min)	Total (m3)
July 26th	0:00	0.31177	897.41
	1:00	0.30292	915.65
	2:00	0.30256	933.88
	3:00	0.29986	952.06
	4:00	0.31818	970.45
	5:00	0.34121	989.57
	6:00	0.39982	1010.66
	7:00	0.49071	1036.85
	8:00	0.42864	1064.23
	9:00	0.42193	1089.87
	10:00	0.4452	1116.05
	11:00	0.47027	1142.51
	12:00	0.41169	1168.87
	13:00	0.43291	1193.42
	14:00	0.4262	1220.4
	15:00	0.39729	1245.52
	16:00	0.50204	1270.51
	17:00	0.50842	1301.6
	18:00	0.50224	1333.03
	19:00	0.4482	1363.14
	20:00	0.39605	1388.77
	21:00	0.32687	1413.26
	22:00	0.29064	1431.94
	23:00	0.33855	1450.42
July 27th	0:00	0.30213	1468.93
	1:00	0.28333	1486.37
	2:00	0.28072	1503.37
	3:00	0.27918	1520.35
	4:00	0.28778	1537.18
	5:00	0.30514	1554.29
	6:00	0.40492	1574.21
	7:00	0.41583	1600.25
	8:00	0.40569	1626.12
	9:00	0.41441	1651.4
	10:00	0.39719	1674.68
	11:00	0.41978	1698.15

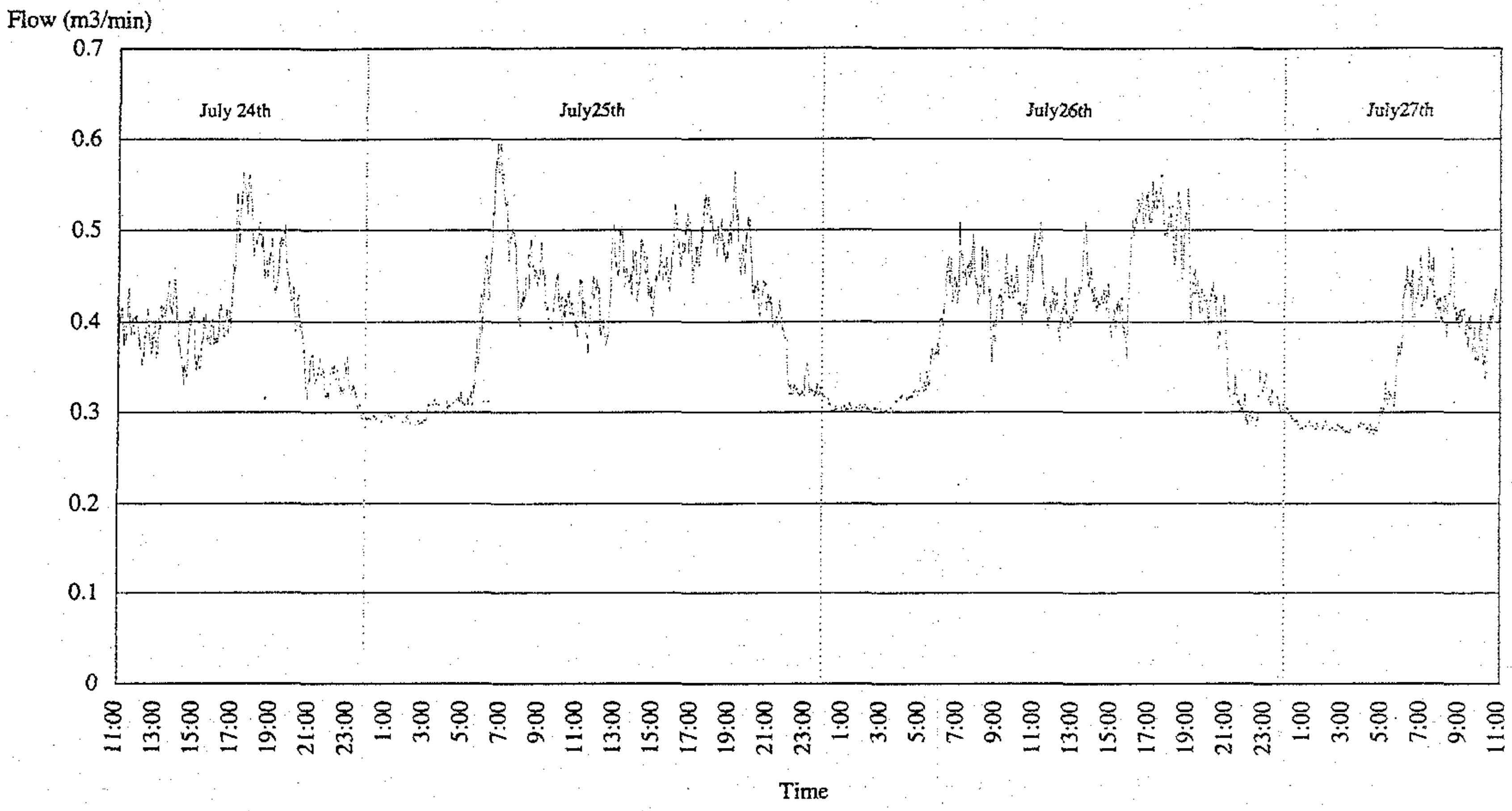


Figure F.8 The Chart of Inlet Flow in Yankin

Table F.4 The Results of Meter Reading in Model Block in Yankin

No.	Household Name	Address	No. of Family	Meter Reading on 24th of July	Meter Reading on 27th of July	Balance	Per capita consumption
1	U Than Aung	No.60 Parami. 8.Ward	5	3307	3309	2	0.13
2	U Myo Myint	No.58 Parami. 8. Ward	7	54	63	9	0.43
3	U Sein	No.66 Parami. 8. Ward	5	5012	5017	5	0.33
4	U Win Lwin	No.68 Parami. 8. Ward	5	33	41	8	0.53
5	Daw Khin Nyein	No.54-B Parami. 8. Ward	6	107	124	17	0.94
6	U Win Lwin	No.68-B Gant Kaw Mying. 8. Ward	5	48	58	10	0.67
7	Daw Khin Aye Kyu	No.1 Gant Kaw Myint 8-Ward	7	4389	4395	6	0.29
8	U Myo Min Htun	No.1-A Gant Kaw Mying .8-Ward	3	5104	5109	5	0.56
9	Daw Khin Than	No.2 Gant Kaw Mying .8-Ward	3	4636	4643	7	0.78
10	U Ohn Kyaw	3.A Gant Kaw Mying .8-Ward	3	14	15	1	0.11
11	U Kyaw Oo	3.B Gant Kaw Mying .8-Ward	5	4140	4146	6	0.40
12	U Soe Than	No.3.C Gant Kaw Mying .8-Ward	5	21	29	8	0.53
14	U Htoo Hling	No.5 Gant Kaw Mying .8-Ward	6	5685	5692	7	0.39
15	Daw Yin Kyi	No.6 Gant Kaw Mying .8-Ward	2	1	2	1	0.17
16	Daw Shu Yin	No7 Gant Kaw Mying .8-Ward	12	6960	6992	32	0.89
17	U Soe Win	No.8 Gant Kaw Mying .8-Ward	6	2240	2247	7	0.39
18	U Han Htwe	No.10 Gant Kaw Mying .8-Ward	2	2296	2299	3	0.50
20	U Khin Thein	No.11 Gant Kaw Mying 8-Ward	4	22	29	7	0.58
21	Daw Pyone Thwzn	No.1 Myitzu Lane 2.8-Ward	6	2482	2485	3	0.17
22	Daw Wai Wai	No.1.B Myitzu Lane 2.8-Ward	8	6220	6234	14	0.58
23	U Ko Ko Gyi	No.12 Myitzu Lane 2.8-Ward	6	50	59	9	0.50
24	Dr.Tin Aung	2.D Myitzu Lane 2.8-Ward	7	26	32	6	0.29
25	Daw Thein Thein Yi	2.D Myitzu Lane 2.8-Ward	10	16	27	11	0.37
26	U Thaung Tin	2.D Myitzu Lane 2.8-Ward	13	58	73	15	0.38
27	Daw Saw Kyi	2.D Myitzu Lane 2.8-Ward	3	14	17	3	0.33
28	U Soe Tint	2.D Myitzu Lane 2.8-Ward	3	54	58	4	0.44
29	Daw Aye Aye Thin	2.D Myitzu Lane 2.8-Ward	15	20	35	15	0.33
30	U Soe Thein	2.D Myitzu Lane 2.8-Ward	2	3	4	1	0.17
32	U Than Aung	2.D Myitzu Lane 2.8-Ward	2	2	3	1	0.17
33	U Myint Than	2.D Myitzu Lane 2.8-Ward	5	18	23	5	0.33
34	U Khon Naung	No.90 Myitzu Lane.2. 8-Ward	6	2401	2406	5	0.28
35	Daw Pyone Thwin	No.90 Myitzu Lane.2. 8-Ward	3	3	6	3	0.33
37	Daw Kyi	No.19 Gant Kaw Mying 8-Ward	2	1004	1006	2	0.33
37	U Sein Hla	No.19 Gant Kaw Mying 8-Ward	3	1930	1932	2	0.22
38	U Kyaw One	No.36-G Gant Kaw Mying 8-Ward	4	1626	1629	3	0.25
39	U Than Htun	No.36-G Gant Kaw Mying 8-Ward	4	1576	1579	3	0.25
40	U Htun Soe	No.36-E Gant Kaw Mying 8-Ward	4	1041	1043	2	0.17
41	Daw Khin Saw New	No.36-E Gant Kaw Mying 8-Ward	5	8	11	3	0.20
42	U Mg Mg Aye	No.26 Gant Kaw Mying 8-Ward	3	2178	2181	3	0.33
43	U Tin Win	No.98 Gant Kaw Mying 8-Ward	7	6535	6542	7	0.33
45	U Kyaw Thein	No.36-C Gant Kaw Mying 8-Ward	4	4057	4060	3	0.25
46	U That Htun	No.98-B Gant Kaw Mying 8-Ward	5	3888	3893	5	0.33
47	Daw Khin May Si	No.36-B Gant Kaw Mying 8-Ward	8	36	47	11	0.46
48	U Shwe Than	No.36 Gant Kaw Mying 8-Ward	5	38	43	5	0.33
49	U Zay Ya	No.1 Gant Kaw Mying 8-Ward	6	3285	3289	4	0.22
50	Daw Khin Khin Sein	No.2 Gant Kaw Mying 8-Ward		692	693	1	
51	U San Thar	No.36 Gant Kaw Mying 8-Ward	6	100	114	14	0.78
52	U Win Thar Htay	No.36 Gant Kaw Mying 8-Ward	5	5	6	1	0.07
55	U Aung Ngwe	No.3 Gant Kaw Mying 8-Ward	4	971	974	3	0.25
57	Daw Khing Khing Cho	No.5 Gant Kaw Mying 8-Ward	3	7015	7020	5	0.56
59	Daw Nu Nu Sein	No.7Gant Kaw Mying 8-Ward	4	15	19	4	0.33
61	Daw Tin Hla	No.101 Gant Kaw Mying 8-Ward	3	1716	1720	4	0.44
63	Daw Aye Kway	No.100 Gant Kaw Mying 8-Ward	6	2169	2173	4	0.22
64	U Paw Htun	No.104 Gant Kaw Mying 8-Ward	4	31	36	5	0.42

Table F.4 The Results of Meter Reading in Model Block in Yankin

No.	Household Name	Address	No. of Family	Meter Reading on 24th of July	Meter Reading on 27th of July	Balance	Per capita consumption
65	U Myint Thein	No.130 Gant Kaw Mying 8-Ward	4	3	4	1	0.08
66	Daw Khin Cho New	No.15Gant Kaw Mying 8-Ward	5	3638	3643	5	0.33
67	U Kyaw Kyaw Win	No.14 Gant Kaw Mying 8-Ward	2	4	4	0	0.00
68	U Khin Mg Cho	No.13 Gant Kaw Mying 8-Ward	2	1534	1536	2	0.33
69	Daw Khin Soe Win	No.10 Gant Kaw Mying 8-Ward	3	5	9	4	0.44
70	Dr. Soe Min	No.111 Gant Kaw Mying 8-Ward	5	654	657	3	0.20
71	U Than Mg	No.101 Gant Kaw Mying 8-Ward	11	1949	1962	13	0.39
72	Daw Khin Khin Thein	No.101 Gant Kaw Mying 8-Ward	5	629	633	4	0.27
73	U Zaw Win	No.101 Gant Kaw Mying 8-Ward	3	8	10	2	0.22
74	U Thar Htun Aung	No.111 Gant Kaw Mying 8-Ward	7	750	755	5	0.24
75	U Hla Than	No.297 Gant Kaw Mying 8-Ward	7		4319	3	0.14
76	Daw Tin Kyi	No.167 Gant Kaw Mying 8-Ward	10	635	645	10	0.33
77	U Moe Kyaw Shwe	No.68 Gant Kaw Mying	4		67	4	0.33
79	U Min Zaw	No.68 Gant Kaw Mying	5	681	684	3	0.20
80	U Htun Aung	No.145 Gant Kaw Mying	5	4638	4647	9	0.60
82	U Ba Htay	No.175 Gant Kaw Mying	6	2058	2060	2	0.11
83	Daw Aye Nu	No.174.A Gant Kaw Mying	5	2814	2821	7	0.47
84	U Thein Win	No.98 Gant Kaw Mying	6	3488	3496	8	0.44
85	U Khin Mg Lwin	No.99.B Gant Kaw Mying	5	6096	6105	9	0.60
87	U Sein Win	No.99Gant Kaw Mying	7	47	56	9	0.43
91	U Khon Phone	No.89Gant Kaw Mying	2	421	422	1	0.17
92	U Tun Shwe	No.629 Gant Kaw Mying	2	145	146	1	0.17
94	U Kyin Shein	No.86 Gant Kaw Mying	10	2373	2378	5	0.17
95	U Myint Htay	No.100 Gant Kaw Mying	10	19	25	6	0.20
96	U Than Ngae	No.68 Gant Kaw Mying	5	811	813	2	0.13
97	U Win Thein	No.15 Gant Kaw Mying	5	6	7	1	0.07
99	U Kyaw Min	No.78Gant Kaw Mying	3	888	893	5	0.56
100	U Tun Aung	No.73 Gant Kaw Mying	4	3274	3279	5	0.42
101	Daw Khin Mar Thin	No.66 Gant Kaw Mying	5	578	587	9	0.60
102	U Ni	No.66 Gant Kaw Mying	9	1170	1176	6	0.22
103	Daw Ohmar	No.15 Gant Kaw Mying	5	2	4	2	0.13
104	U Thein Aung	No.679 Gant Kaw Mying	9	356	362	6	0.22
105	U Thaung Shwe	No.47 Gant Kaw Mying	4	1950	1963	13	1.08
106	U Khon Phone	No.48 Gant Kaw Mying	4	4	5	1	0.08
107	U Than Htun	No.267 Gant Kaw Mying	5	3477	3482	5	0.33
108	U Lin Shein	No.267 Gant Kaw Mying	4	3579	3588	9	0.75
109	U Mya Wai	No.267 Gant Kaw Mying	6	3287	3294	7	0.39
110	U Sein Phe	No.267 Gant Kaw Mying	6	2406	2415	9	0.50
111	Daw Yin Yin San	No.267 Gant Kaw Mying	4	5	8	3	0.25
112	U Nay Min	No.8 Tha Zin Mying -8-Ward	7	5	23	18	0.86
112	Daw Win Han	168-B Myitzu lane	2	1329	1330	1	0.17
113	Daw Khin May Than	No.6 Tha Zin Mying -8-Ward	5	3216	3219	3	0.20
114	Daw Ni Ni Tin	No.4 Tha Zin Mying -8-Ward	8	8076	8085	9	0.38
115	U Nay Htun	No.2 Tha Zin Mying -8-Ward	5	284	289	5	0.33
116	Daw Khin Moe Moe	No.116 Thariphi	4	4574	4580	6	0.50
117	Daw Soe Win	42.D Thariphi	4	342	342	0	0.00

Table F.4 The Results of Meter Reading in Model Block in Yankin

No.	Household Name	Address	No. of Family	Meter Reading on 24th of July	Meter Reading on 27th of July	Balance	Per capita consumption
118	U Aung Phay	42 Thariphi	5	133	133	0	0.00
119	Daw Mya Gyi	674 Thariphi	5	1274	1288	14	0.93
120	U Mya	115 Thariphi		676	682	6	
121	U Mg Mg Htun	670 Thariphi	10	1593	1595	2	0.07
122	U Htay	97 Thariphi	4	611	614	3	0.25
123	Monastry(1)			46	99	53	
124	Monastry(2)			20	31	11	
125	School			4	21	17	
126	Monastry(3)			9	14	5	
	U Win Tin	( ) Myitzu Lane		38	51	13	
	Monastry	1 Hantkaw Myay 8-Ward		8	13	5	

2.3.3 The model block in Bahan

The results of measurement in this model block are as follows:

- Inlet Flow: 4060m3
- Consumption: 1629m3
- Balance: 2431m3

(a) The characteristics in this model block are quite different to other two model blocks. The flow pattern of this Model Block cannot be considered as representative of the Yangon distribution pipeline. The fixed volume of flow such as the flow of the transmission pipeline is distributed without taking the influence of the consumer's usage.

(b) The above balance can't be said as UFW when it is judged by flow chart which it was expanded from inlet flow measurement. According to the flow chart, several inlets exist. The inlet flow data is shown in Table F.8.

(c) A high flow level occurs on both directions at the inlet. The flow velocity at the inlet is 8m to 10m per second in a pipe measuring just 6-inch.

(d) 16 leaks were detected.

2.3.4 The model block in Tamwe

The results in model block in Tamwe lead to the following conclusions.

(a) According to the logging data of ultrasonic flowmeter, 529m3 (a) of water entered into the model block over a period of three days.

(b) The amount of water consumed for three days was 419m3 (b).

(c) There are no illegal connections or public taps in this block. But, a sucktion pump was observed in each house. The fact that the pumps are working even during the night, the minimum night flow method could not be employed. Therefore, 110m3 (20.8%) (a) – (b) of the balance will be able to consider as the leakage volume for three days. This flow is equivalent to 25.5 liters per minute.

(d) 4 leaks were detected in this model block.

3 PIPELINE INVESTIGATION

3.1 PURPOSE

The purpose of this investigation was to establish the characteristics of the distribution system with regard to the length of different pipelines, the type of pipe materials used and their age.

3.2 METHOD

The study team in collaboration with YCDC staff collected data on existing main pipelines in 26 of townships. This assessment was based on the pipeline network drawings drawn by YCDC in 1995. The type of materials used was assessed .....

3.3 RESULTS

The results indicate that the majority of transmission mains are of cast iron (Table F.5).

Table F.11 Existing Pipeline Mains in Yangon

Pipe Material	Length (ft)	Share (%)
Cast Iron (CIP)	1,732,409	69.0 %
Steel (MSP)	126,150	5.0 %
Ductile Iron (DIP)	101,496	4.0 %
Galvanizing Iron (GIP)	134,557	5.4 %
Polyvinyl Chloride (PVC)	287,135	11.4 %
Concrete (RCP)	130,619	5.2 %
Total	2,512,366	100 %

Source: Study Team (2001)

The share of existing pipe materials is shown in Figure F.9, and the lengths of existing pipeline mains are shown in Figure F.10.

The details of pipeline investigation in each township are shown in Table F.6.

Figure F.9 The Share of Existing Pipe Materials

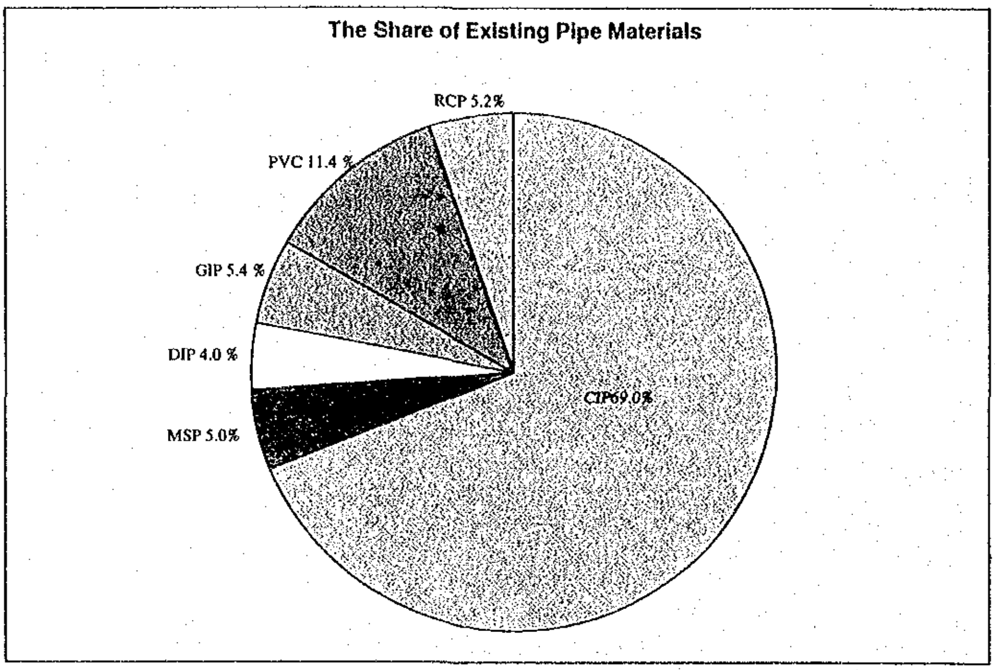
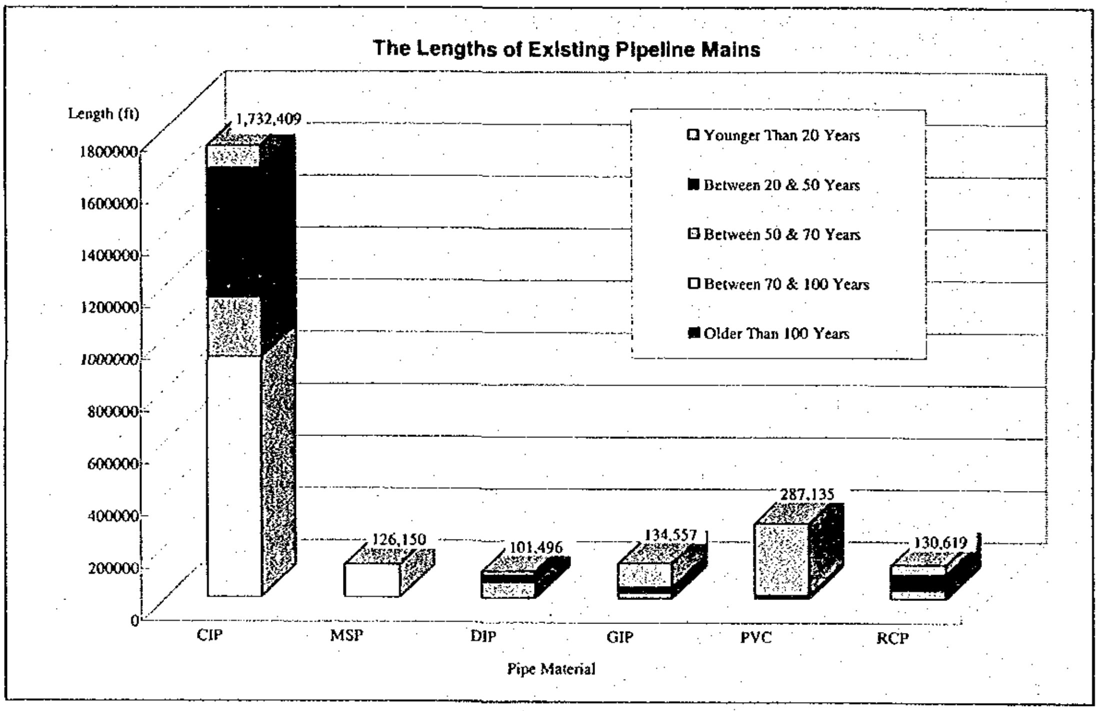
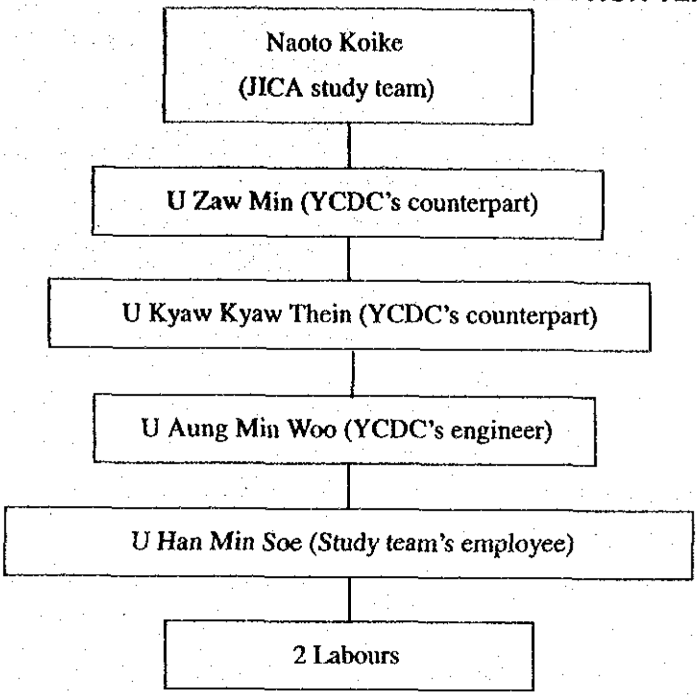


Figure F.10 The Lengths of Existing Pipeline Mains



4 LEAKAGE DETECTION

4.1 ORGANIZATION CHART OF LEAKAGE DETECTION TEAM



4.2 LEAKAGE DETECTION

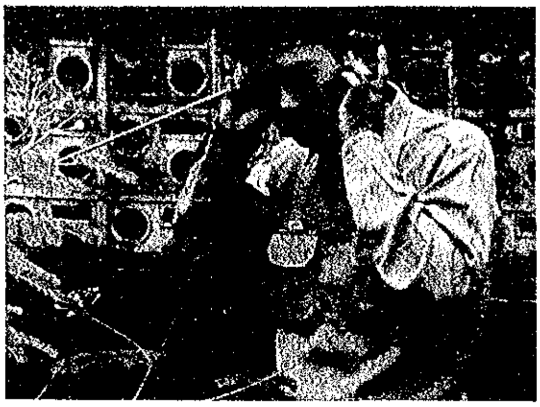
Leakage detection was carried out in the four model blocks for the purpose of the technical transfer. The technology transferred about the following items.

a. The recognition of the leakage sound
b. Reporting

a. The recognition of the leakage sound

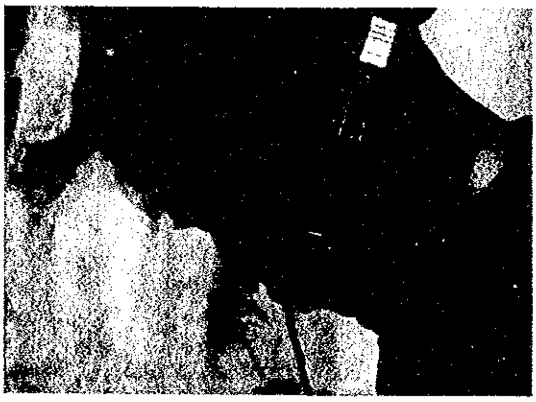
a-1 Sound Detection using by Sounding Bar

In this study, as for the recognition of the leakage sound, sounding bar which is the fundamental instruments has been used, which are not the advanced leakage detection instrument to analyze automatically, which recognize the smaller leakage sound with human ears. The work which the sound of the leak is recognized by sounding bar is shown in the following photo.



b-2 Sound detection using by Leakage Detector

Leakage sound propagating to the ground will be detected on the road surface to detect the leakage for which to occur in the laid distribution pipe or service pipe in the road. It will be detected the sound of leakage using by leakage detector in 0.5-1.0m of spacing. The principle of the leak detector detects the propagating sound of leakage which occurs from the leaks by pick-up, and makes that signal amplify electronically. Then, the existence of the leak is judged by the indication of indicator on the main body or headphone.



b. Reporting

The training of writing the leak detected as the reporting in Leakage Report was done. Leakage survey work was carried out in the four model blocks which were selected as actual leakage volume measurement. Leakage Report which wrote each detected leakage are shown in Figure F.18.

4.3 MANUAL FOR LEAKAGE SURVEY

4.3.1 Current Situation

Leakage survey work was completed. Leakage survey team in JICA study team assesses the overall condition of leakage as follows:

- Because the scaled pipe network drawing which the details are drawn in doesn't exist in YCDC, the laid pipelines couldn't be traced. Thus, the point of leakage couldn't be specified accurately.
- Under the low system pressure condition, leak detection work is generally easier in service connection pipes than in distribution mains.
- There have been observed many instances of so-called spaghetti service connection pipes. This increases the chance of leakage.
- There have been also observed many instances of PVC service connection pipes being exposed to the sunlight or the ground without protection. This leads to the deterioration of the pipes.
- Leaks from several PVC service connection pipes were detected. This implies that there is an obvious need for improvement of the methods.
- The distribution mains pipe was found to have an earth covering depth around 3 feet. Traffic condition in Yangon is heavy and intense. This current practice may need to be dissolved to protect pipes from being damaged.

4.3.2 Ward

According to the YCDC's pipe network drawing, 26 of township which the pipe network exists in are shown in the following.

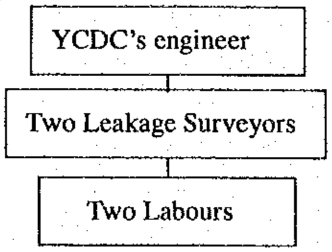
No.	Township	No. of Ward	No.	Township	No. of Ward
1	Ahlone	11	14	Mayangone	10
2	Bahan	22	15	Mingalardon	31
3	Botataung	10	16	Mingalartaungnyunt	20
4	Dagon	6	17	North Okkalapa	19
5	Dala	22	18	Pabedan	11
6	Dawbon	14	19	Pazundaung	10
7	Hlaing	16	20	Sanchaung	18
8	Insein	21	21	Seikan (Port)	3
9	Kamayut	10	22	South Okkalapa	13
10	Kyauktada	9	23	Tarmwe	20
11	Kyeemyindaing	21	24	Thaketa	12
12	Lanmadaw	12	25	Thingannyunt	38
13	Latha	10	26	Yankin	16
				Total	405

JICA study team will propose the above Ward as the leakage management area.

4.3.3 Organization of survey team

JICA study team will propose that each leakage survey team will be four persons as shown in the following.

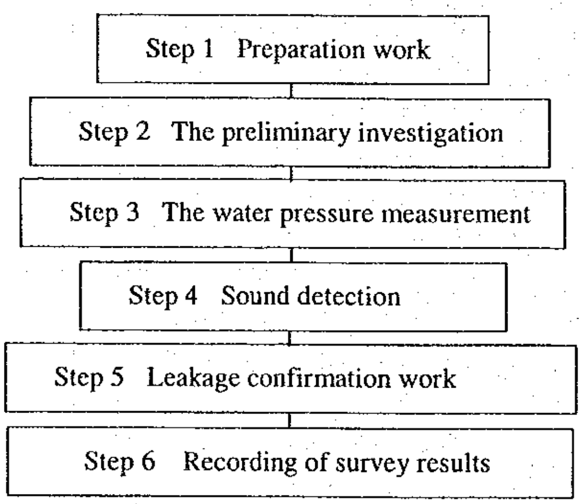
Figure F.11 Proposed organization chart



4.3.4 Procedures for leakage survey

The scaled pipe network drawing will be necessary to specify the point of leakage in the laid pipeline accurately. Therefore, JICA study team will recommend that the scaled pipe network will be prepared. As a tentative measure, leakage survey should be concentrated on the detection of the visible leakage. In the future, JICA study team will propose that the leakage survey in Yangon will be conducted in the following steps.

Figure F.12 proposed procedures for leakage survey



Step 1 Preparation work

To begin with, the schedule for leakage survey should be made. Before leakage survey, it is announced to get cooperation and understanding in the residence of the investigation area.

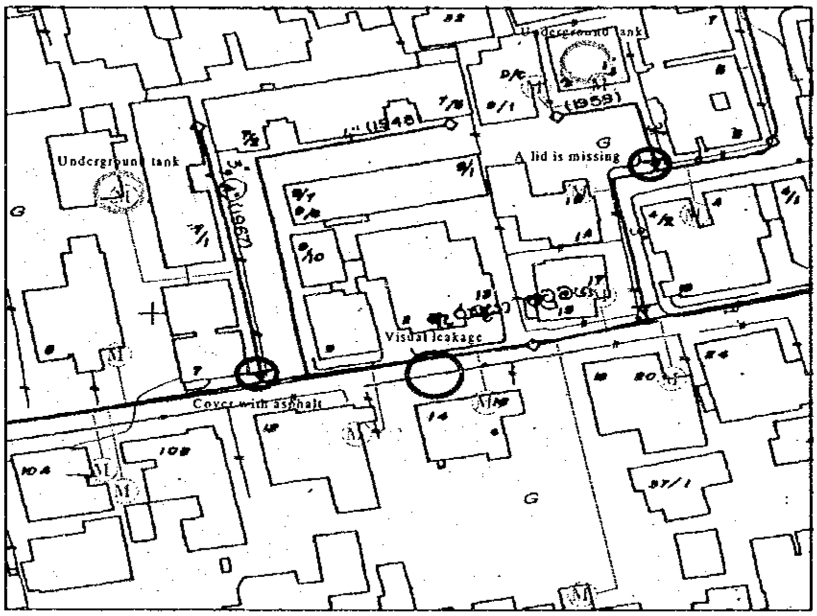
Step 2 The preliminary investigation

It will be checked the YCDC's pipe network drawing of the investigation area with the field. The check items those are necessary for the investigation is shown in the following.

- The locating confirmation of buried distribution pipelines
- The locating confirmation of the valve, the fire hydrant and the public taps (If necessary, do the function test)
- The grasping of the topography, traffic density and the noise
- The confirmation of the cable for telecommunication or electric power
- Detect the visible leakage

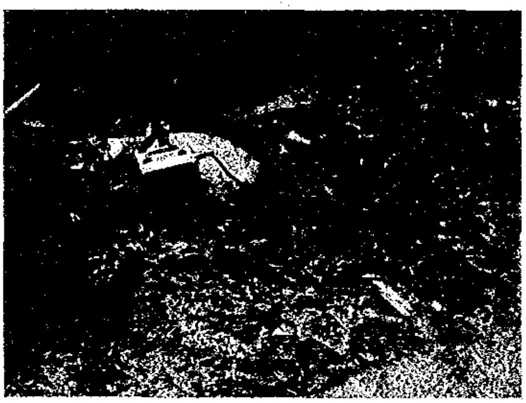
It should be shown about the meter location and the service pipes (as much as possible) of each house where investigation will be done in the pipe network drawing. This will be the improvement of maintenance. Note will do the results of the preliminary investigation in the drawing.

Figure F.13 Proposed preliminary investigation note example



Step 3 Water pressure measurement

Generally, the recognition of leakage sound is difficult when the system water pressure is less than 0.5kgf/cm2. During the survey period by JICA study team, there were some places that the system water pressure was less than 0.5kgf/cm2.Therefore, it should be measured the water pressure by the water pressure recorder at several points in the investigation area as below photo. (Minimum 24 hrs)



The results of measured water pressure will be:

- To make the distribution map for water pressure in the investigation area
- To grasp the conditions of water pressure in the investigation area
- To setup the working hour for leakage survey in investigation area

Step 4 Sound detection work

However, it is general to recognize leakage sound in the current leakage survey technique. From this standpoint, the first step of the leakage survey in Yangon should do sound detection work. Sound detection work, it is the work of recognizing leakage sound from valve, public taps and fire hydrant mentioned in YCDC's pipe network drawing in the surveying area. this is a basis when the leakage survey is carried out.

Though, basically the leakage survey will be carried out at the daytime, it will be changed to carrying out at the night when the facilities such as valves, public taps and fire hydrant will exist in the location where is high traffic density, or many extraneous noise.

During the survey period by JICA study team, there were many locations where it was buried by the asphalt and the soil accumulated in the valve box, and it interfered in the survey as for the conditions of the facilities in the surveying area. JICA study team will recommend that it will be maintained the above facilities such as valves, public taps and fire hydrant from viewpoint of maintenance or at the time of emergency.

JICA study team will propose that there are following two instruments in the sound detection.

a. Sounding Bar

To recognize leakage sound, sound detection work will be carried out at the following facilities.

- Valves
- Public taps
- Fire hydrants
- Domestic water meter

b. Leakage Detector

The following will influence the sound detection using by leakage detector.

- The noise from surrounding
- Usage water
- The change in buried depth of the pipes
- The point of bend in the pipes
- The point of reducing pipe diameter
- Weather conditions as wind, rain and so on
- The poor system water pressure

To detect the point of leakage by using leakage detector, the training and the experience should be necessary.

Step 5 Leakage confirmation work

Any extraordinary sound, if detected, will be resurveyed to confirm that the sound is indeed from leakage.

The propagation velocity of the sound is varied in each pipe material. The correlator calculate the point of leaks from above basis by catching the leakage sound which propagates pipelines with two sensors which install the point of leaks between. After leakage sound is confirmed, the locations that install the sensors in the location to put the point of leaks between are selected.

The locations to be installed the sensors are:

- Fire hydrant
- Valve
- Domestic Meter
- Public Tap

The accurate data will be entered as much as possible because it will influence the detection accuracy greatly.

Entering data to the correlator is:

- Pipe material
- Pipe diameter
- Length between two sensors

The leakage confirmation work using by correlator will be influenced by the following.

- The noise from surrounding
- Usage water

When it will be conducted the leakage confirmation work by using the correlator, it will note to the above. The Study team will recommend that the point of leaks will be specified by using the correlator.

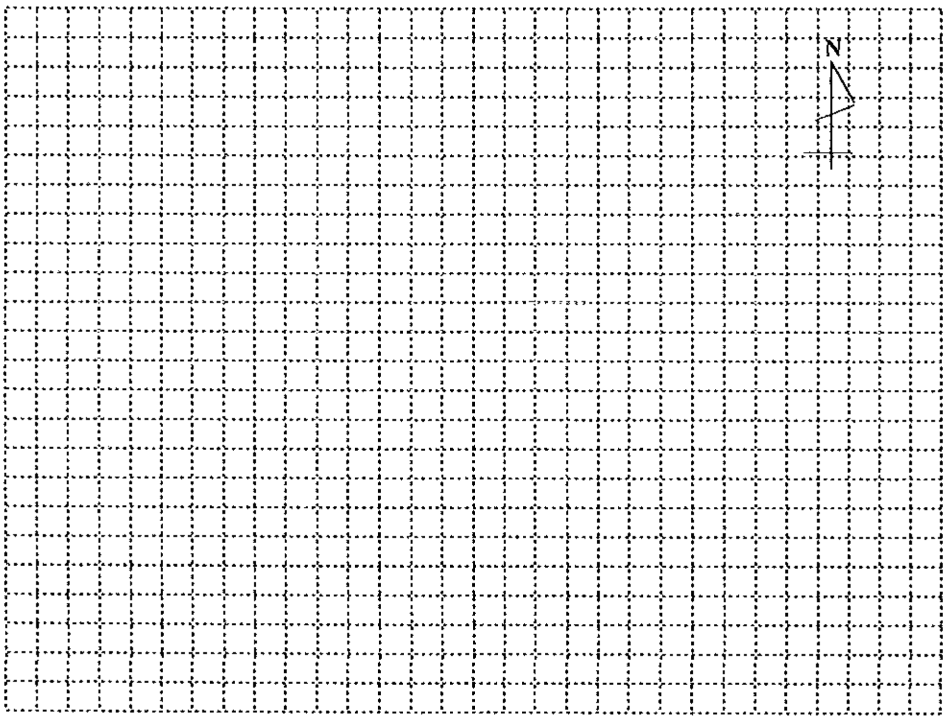
Step 6 Recording of survey results

As for the visible leakage and the underground leakage that it is detected by the leakage survey, the leakage report will be made and reported to the leakage repair group. At the same time, it is important to record the leakage report.

When leakage will be repaired, the cause of the leakage and occurrence location will be confirmed. The analysis related to the leakage from those data will be conducted, and it will be available for the prevention of the leakage.

Leakage Report

Name of Lane		Leakage No.	
Nearest House			
Scale of Leakage (Estimate)	Large / Medium / Small		



Date(s) of Repair		No. of Repair Workers	persons	
No. of Time Required for Repair		hrs		
Materials Used for Repair				
Pipe Material	1.CIP	2. PVC	3.GIP	4.Others( )
Pipe Diameter		Depth		
Landownership Classification	1.Public	2.Private		
Pipe Classification	1.Distribution Pipe	2.Service Pipe		
Surface	1.Asphalt	2.Concrete	3.Soil / Gravel	4.Others
The point of leakage	1.Pipe Body 5.Service Pipe	2.Pipe Joint 6.Ferrule	3.Valve 7.Water Meter	4.Fire hydrant 8.Others( )
Comments (Sketch) :				

APPENDIX G

UNACCOUNTED FOR WATER CONTROL PLAN

APPNDIX G
UNACCOUNTED FOR WATER CONTROL PLAN

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1 OVERVIEW

1.1 INTRODUCTION

Efforts to reduce excessive unaccounted-for water (UFW) in many countries may be hampered by several factors: lack of awareness of the practical possibilities and the potential financial and operating benefits by senior management; lack of motivation at the operational level; and, particularly, lack of resources. This UFW control plan is intended to clarify the issues and present a mechanism for YCDC managers in making the resources available to improve UFW reduction and control, as part of the overall Master Plan for improvement of the water supply system in Yangon.

Often, a Water Supply utility has many problems – as much political and institutional as technical - but, first and foremost, the objective will be to provide enough water, at adequate pressure over the whole area served, to meet demand as it increases. For this the management needs the resources to meet both investment and operating costs.

Typically, an UFW project faces a situation in which the Water Supply Utility concentrates on the established policy of improving water supply by developing new resources or by expanding existing works. As a result, data relating to the existing system is not sufficient for a reasonable assessment of the supply and demand situation and figures on the quantity of water produced and consumed are so inaccurate as to be unusable or call for a good deal of interpretative estimation.

So if UFW control is to be taken seriously and achieve its potential, it is necessary as an essential beginning to accurately measure and assess the data to determine immediate and long-term strategy. The better the information available, the more directed and cost-effective will be the investments and network operations. It is to be noted that this need for good information about the system applies equally to the general category of network management as to UFW control, of which the latter is really a subsidiary component.

One aim of this UFW control plan for Yangon is to propose a method by which step-by-step, progressively more accurate data is obtained and can be analysed for operational and management decision-making. A clear picture of the existing situation, at any point in time, will facilitate the development of a strategy for whatever improvements are warranted. These may be in the area of physical supply conditions or in the improved collection of revenue, including un-assessed consumption.

If the production of accurate data demonstrates the existence of either an excessive loss of revenue from water consumed or an excessive loss of water from leakage, or indeed both types of loss, a strategy should be developed and implemented by stages to effect those improvements found to be economically justified.

The framework of such a strategy is proposed in this document, but it will rest with the implementing departments to decide the detail, most appropriate to their circumstances and to retain the flexibility to adapt the plan as it progresses.

1.2 OVERVIEW OF UNACCOUNTED FOR WATER (UFW) STRATEGY FOR YANGON

UFW is a key activity in any water supply undertaking that exercises any degree of demand management. This will be especially valid in Yangon where the present situation is such that the demand exceeds supply and where supply management is a problem with no ready sources of increasing supply to a level greater than the potential demand.

1.2.1 Integrated System of UFW

To be fully effective the UFW system must be integrated into a unified approach through the whole organisation covering the supply chain from water sources through treatment plants and pumping stations to service reservoirs and distribution networks

Water loss control should be an integral part of network operations and not treated as a separate, independent function. Initially, it will be necessary to have specialist teams working on the day-to-day UFW operations, but this should eventually be integrated in with the other departments. Even during the earlier stages of having a specialist team or teams, the normal operating departments will be required to provide close co-operation.

1.2.2 Importance of Reliable, Accurate Base Data

All network operations and new works planning will be undermined and especially UFW control by lack of and inaccuracy of the basic data contained in drawings, maps, schematics databases etc.

At present, there is little or no reliable data available for the Yangon water supply system. This will have to be rectified and the collection of useful data and its application should commence immediately to begin building up a historical profile record.

This is even more the case when network analysis is used as a tool for planning and monitoring the system

1.2.3 Flow Measurement and Water Balance

Some greater or lesser degree of flow measurement and statistical data collection is essential to running the network. Without at least production metering the water supply quantities are pure guesswork. Once UFW control is included as part of the department's operations in order to improve efficiency, then this becomes even more vital.

1.2.4 Use of Technology

Technology should be used to the level of sophistication appropriate to the situation and based on a cost/benefit assessment. Expensive equipment and computerised systems are not an end in themselves and will not produce results without the correct methodology and application. They will have their place at some point in the evolution of the plan, but only in conjunction with trained, motivated personnel implementing an effective strategy.

1.2.5 Inclusion of Principles of UFW in Capital Expenditure Planning

For Yangon that is in many respects starting from scratch in terms of network management and network rehabilitation, much of the cost of setting up UFW control will be included in the Capex programme for general improvement

Similarly, much of the work necessary to implement the changes will already be contained within the network analysis and water supply planning if UFW principles are incorporated and applied at this early stage.

For example, sectorisation of the network and installation of all required valves and flow meters for district metering and zone control will be included in the network improvement design and construction, provided that the necessary design criteria are incorporated at this stage.

1.2.6 Public Education and Community Development

The situation in Yangon is not simple and the population obtains water by a variety of different means. The progressive transfer to an urban piped water supply for all will affect the population and the level of success will be influenced by their responses.

Especially important will be the attitude to and perceptions of the public to their water supply and the importance of good housekeeping, plumbing work etc. to ensure that waste is minimised.

To this end, it is important that the public be involved and informed and that therefore public education and project publicity, in some form, be included as part of the general as well as UFW activities.

1.2.7 Calculating UFW

UFW is taken as the difference between the net volume of water put into production and the amount of water used legitimately. UFW is usually quoted as a percentage of net production. When expressed thus, comparison of figures for different systems can be misleading, and such figures must be treated with caution. However, since percentage figures are the standard form of expression, they are used in this plan. UFW applies only to piped distribution networks and is not applicable to independent and rural type point sources of water supply.

1.2.8 Continuity of Supply

When a continuous supply of water under pressure is not available, only limited tangible improvements in domestic metering or reduced leakage can be achieved in the short term. Nonetheless, much can be done in the areas of checking basic data, updating maps and records, and improving overall maintenance, which will be invaluable when the availability of water improves. A start can also be made on reduction of UFW in any areas where supplies are continuous.

When a continuous supply of water is available during a limited period of the year, much more can be done through a logical, phased program to identify the extent and the nature of the problem and to achieve positive results in UFW control.

This situation applies very much to Yangon. This principle must be borne constantly in mind as a parameter for planning UFW control and applied in the selection of areas and activities. This constraint will be considerable in the early stages of implementation of this plan, but should progressively be eliminated as the service improves and expands to provide 24 hour, reasonable pressure supply to the whole supply area.

1.2.9 Recognition of the Problem

Where the calculation of UFW shows that a problem exists, it has probably existed for so long that it is assumed to be inevitable and nothing much can be done. Control is seen as a matter for attention sometime, but not now.

Some authorities cite UFW levels as high as 50 percent or more of all water produced; if UFW levels are above 25 percent, there is a problem that can no longer be disregarded. What action should be taken to reduce UFW levels is a matter for case-by-case judgement, bearing in mind that the decision must rest ultimately on its cost effectiveness.

1.2.10 Strategy for Control

It is important to remember that UFW control is not a technologically sophisticated nor a once only process. Control of UFW entails the continual repetition of a series of simple, logical processes and tasks to obtain increasingly accurate detailed data that facilitate ever-more-efficient detection of deficiencies.

The following sections develop the strategy proposed in this plan.

1.3 PRESENTATION OF THE PLAN

To facilitate the use of this document by different parties interested in varying levels of detail, the format has been arranged as follows:

- A summary of the present situation of the Yangon city water supply and YCDC activities as related to UFW: to provide the context in which this plan is to be initiated
- A brief, explanatory discussion of the principles and activities of UFW control in general terms without specific reference to Yangon
- A brief presentation of other related activities affecting UFW control
- The specifics of the strategy and particular activities proposed to be carried out in Yangon to work towards the optimum UFW control in the context. This is in several phases over the period to 2020
- The organisation and personnel proposed to enable YCDC to implement the plan
- Outline consideration of approach to cost-benefit balance of UFW control
- A preliminary timetable and checklist for the initial stages of the plan, including identification of priority projects with planning cost estimates

2 HISTORICAL CONTEXT & PRESENT SITUATION

The following section summarises the present situation in Yangon as it relates to the control of UFW. For a more detailed review, the previous report by this Study team, the first Progress Report of August 2001 should be consulted. Here only the key points are reviewed.

The first and most critical point of the current position is that YCDC has no particular strategy nor group of staff specifically responsible for UFW control planning and implementation.

The following is an extract from the plan prepared for Yangon in 1980 by Metcalf & Eddy. It is reproduced here to illustrate the longevity of the present situation, since the same comments could be repeated almost verbatim today.

2.1 EXTRACTS FROM METCALF & EDDY REPORT 1980

A satisfactory, efficient and economically viable water supply organisation cannot be achieved in Rangoon merely by increasing the source capacity and providing an adequate distribution system. A number of changes will be required in the RCDC organisation before success can be achieved. The intermediate and higher levels of staff will have to be increased in number and technical expertise. Expenditure on the maintenance, repair and replacement of meters, pumps, pipes, reservoirs, valves, hydrants and other facilities will have to be increased. A vigorous programme to reduce leakage and wastage is essential. RCDC must also work to eliminate unauthorised connections, enforce the payment of bills and remove the very many plumbing fixtures, which have the potential for contaminating the water in the distribution system.

2.1.1 Lack of Basic Data

RCDC have agreed to provide the data on which the study is to be based, but they do not have reliable data on water production and consumption. None of their sources of water are metered and a negligible amount of the water supplied to the public is metered. Some of the water production and water sue data provided for the study has been found to be incorrect. These problems have caused delays while additional data have been collected and alternative approaches improvised.

There are about 50,000 military personnel and dependants living in fenced areas reserved for the armed forces (Cantonments). Water is supplied to these areas through several pipes of from 4 to 12 inch diameter. One or more pumps extract water for each of the military supplies from the principal transmission mains. Some military areas also have their own wells in addition to the RCDC supply

2.1.2 Water Losses

The water supply system in Rangoon is old. There is no systematic effort to identify and repair leaks. Valves are not operated or repaired and many valves are known to be inoperable or leaking.

House connections are often made by private contractors, without authorisation or supervision.

Carefully monitored and operated water systems in Europe and USA strive to keep the percentage of unaccounted for water below 25 % of production. It is not difficult therefore to believe that in Rangoon half the water produced cannot be accounted for. In the case of Rangoon however, the loss of more than half the water produced must be viewed in the context of the existing low pressures in the distribution system and the short period of water service each day. If the pressure at standpipes were increased to 30 psi, leakage from Water mains would also increase if pressures and hours of service are increased and waste in private residences could increase considerably.

2.2 YCDC UFW & Leakage Control Present Situation

The following summary gives the key points determined during the study of the present situation in Yangon. These are presented briefly to set the context in which the UFW control plan has been designed, since these are the most important factors relating to Yangon and YCDC.

2.2.1 Current Policy

Under the present arrangements, there is no definite policy, relating to UFW control planning and implementation. This reflects the overall network management situation, which can be characterised as a policy of "firefighting". The network is not actively monitored and managed, rather, staff are on standby until a problem arises and then action is taken.

The key present policy points are:

- Active Leakage control has never been a policy
- YCDC do not have a definite policy about UFW or leakage control
- There are some factors of leakage control included as part of the network operations
- Passive leakage control is the practice now as a form of default policy
- No flow measurement Policy & no attempt to evaluate UFW is practised

2.2.2 Current Practice

Arising from the absence of an active policy for UFW control, the current practice relies largely on passive leakage control, as an incidental part of the duties of network maintenance staff in townships. No great efforts are made to look for leaks nor to evaluate other elements of UFW.

However, once a leak is identified, repairs are effected quickly by either township staff or the "major" repair team. This is a timely response and minimises water lost once the leak is found, but the teams are under-equipped and do not have the necessary materials to make proper repairs. Mostly, the methods are ad hoc and there is a high risk that the leak will recur.

The key points relating to current practice are:

- There are no special teams or sections whose job is leakage control

- Leakage inspection and minor repairs are part of the duties of the network teams in each township
- Detection of leaks depends on seeing water on the ground surface
- If the repair is too big for the township to do themselves, they inform HQ who send a special team.
- Most common repairs are lead joints on cast iron pipe
- Repair teams are not properly equipped and often not able to make proper repairs

2.2.3 Customer Use in the Network Supply Area

Customer use and installations is a subject in its own right, not least because YCDC does not have direct control over the pipework and fittings. In Yangon, there is a lot of leakage evident on service pipe lines and wastage by consumers.

The following key points were established in the assessment of the present situation:

Metering

- Most people pay a flat rate tariffs with only two classes: so there is no incentive to be careful about water use
- Not all large users and commercial customers have meters, despite their relative importance in consumption
- A big element of consumption goes to large unaccounted for connections which are probably institutional, including military bases
- YCDC policy is for all new connections to have meters, but the policy on metering of existing connection is not clear
- Only 23% of consumers so far have meters out of 112,000 total
- Meter replacement occurs on 10% of installations annually due mainly to damage by sediment and grit

Service Pipes

- Service pipe lines tend to be long and with quite a lot of leaks
- Customer responsible to repair his own service line directly from YCDC main pipe
- Important part of losses is on service pipes, because:
  - Length of lines
  - Vulnerability to damage
  - Quality of materials
  - Quality of installation

Connections

- YCDC staff report leaks on service pipes and customer has short period to repair
- But monitoring and enforcement is evidently incomplete
- Regulations for standards of customer installation unclear
- Associated with regulation, there is no public information or education to advise

customers of what is required and what are the benefits

So many of the service pipes seem to be very long, because the YCDC network is severely lacking in secondary and tertiary mains.

2.2.4 Present Network Conditions

It has been estimated that the present service coverage by the network is about 36% of the total population. Even within this low figure, the service has limitations with the following problems:

- Network data is out of date or incomplete
- Generally system pressures are very low, even in areas with so-called 'good pressure'
- Large areas have intermittent service
- To conserve supplies, quite a lot of valve operations are made each day to limit the service
- These factors keep leakage down to very low levels relative to what could be expected if the service level was satisfactory
- Infrastructure Condition is not good, because:
    - Old age of network
    - Majority of joints are lead-caulked
    - Lack of investment in network improvement for a long time
    - Lack of operations & maintenance expenditure
- The drawings do not fully and accurately indicate the situation of the network in the ground

An important factor is unrecognised off-takes from the transmission mains, typically 6" or 8", particularly along the 56" Gyobyu pipe, which is flowing half full by the time it reaches the airport diversion. This must mean a lot of water that has been put into supply is diverted before this point; probably for consumption.

2.3 ESTIMATION OF UFW

The current level of UFW can only be estimated quite approximately, due to the lack of data. An overall estimate of production and consumption gives the following result:

Production	360 + 40 =	400 Mld (average daily flow)
Consumption		145 Mld (average daily flow)
UFW Volume		265 Mld
UFW Ratio		65 %
Network Efficiency		35 %

These results are subject to large uncertainties, but nonetheless serve to demonstrate that the UFW levels are very high and that reduction is very likely to be economically viable. This is especially the case, given the present shortfall in water supply so any increased accounted for water will be used by existing or new consumers.

UFW Components

UFW is split between non-physical and physical (leakage) losses, though the division cannot presently be calculated given the lack of data. As a rough estimate, it is expected that the two elements are divided fairly evenly at present.

The physical losses are relatively low at the moment, because of the poor supply pressure and the limited hours of service. Improvement of service will result in the increase of leakage.

The non-physical losses may not be so severe as they appear at present with such limited information on consumption.

3 PRINCIPLES & ACTIVITIES OF UNACCOUNTED FOR WATER CONTROL

This section sets out to present in general terms an explanation of the principles and activities related to UFW control programmes. No specific reference is made at this stage to the situation in and plan for Yangon, which will be detailed in subsequent sections. It is based on a review of reports and publications on the subject of UFW control and planning.

For those already familiar with the subject or concerned only with the UFW plan of action for implementation by YCDC, this section should be used only for reference.

3.1 BASIS OF UFW AND DEFINITION OF TERMS

3.1.1 Basis of Unaccounted-for Water

It is essential first to clarify what is meant by "unaccounted-for water (UFW)." It has been defined as:

"The difference between net production (the volume of water delivered into a network) and consumption (the volume of water that can be accounted for by legitimate consumption, whether metered or not). The definition is simple, but determining the true figure can be difficult.

It includes leakage, or "physical" loss, but also under-registration or misreading of meters and supplies through illegal connections, or "non-physical" loss.

There has been some confusion in the past as to whether, in systems where domestic supplies are metered, the volume of water accounted for should include water supplied without charge for central and local government establishments and for public purposes such as fire fighting, parks, fountains, lavatories, flushing streets, and so on. All such water can be accounted for and has to be included in consumption figures.

Confusion has also arisen in countries where domestic supplies are not fully metered. In these countries there has been a tendency to regard all UFW as water lost through waste, (that is, not through leakage only), and to disregard the non-physical losses resulting from under-registration of bulk supply, industrial, and commercial meters, even though such losses may represent a significant percentage of the total supply.

For the preparation of this action plan, unaccounted-for water is defined as comprising the following:

- Water consumed but not recorded by consumers' meters or otherwise accounted for in some way, by government, public or other use. This is referred to as a "non-physical" loss and is reflected in lost revenue. It includes water consumed through illegal connections.

- Water lost through leakage, also referred to as physical loss. This is a resource loss and is reflected in the cost of production.

Wasted water, sometimes simply called "waste," is water that is truly lost for reasons such as leakage.

When domestic supplies are not metered much attention is paid to reducing waste other than leakage, whether it is wilful or not. When domestic supplies are metered, waste by the consumer is sometimes not regarded as a serious matter because it is assumed that the water is paid for. This assumption is probably not justified, because the rates of flow from waste whether from a dripping tap, an overflow, or an underground leak, may be too low to be recorded by a meter, even though the volumes are significant because of the continuity of flow.

Furthermore, if the meter is not located outside the property boundary or at the point of transfer of responsibility from the water supply utility to the customer, there may well be leakage on the service pipe that is not recorded by the meter.

Waste also occurs in government institutions, and should be discouraged by levying charges according to meter readings. For this reason, among others, all institutional users should be metered in the same way that commercial and industrial consumers should all be metered.

Waste that is actually recorded on consumers' meters and sold may be acceptable when surplus water exists, but not when there is a scarcity and reduction of waste could defer new capital expenditure.

Control of waste, as indeed of UFW, normally has to be justified on economic grounds. In some situations a severely progressive charge for increased consumption will discourage excessive water use and prompt early attention to defective fittings. The tariff however, must be such that it costs more to use water needlessly than to have fittings repaired.

Wasted water is a conservation loss and affects the cost of production. Waste other than underground leakage may be best controlled by the reasonable, but strict and consistent application of plumbing codes and bylaws. Public education and co-operation are essential to minimise losses from defective fittings and misuse of public standpipes or other free, un-metered supplies.

Comparison of UFW figures between systems where domestic flows are metered and those where they are not is not meaningful. In well-managed un-metered systems, leakage or physical loss is usually the predominant factor, whereas in metered systems, under-registration and metering illegalities, or non-physical loss, may be a significant, if not a dominant, factor. Such comparisons are also meaningless because of the often doubtful reliability of data in un-metered systems.

Assessing correctly the value for UFW in any system is often difficult, since in many instances considerable volumes of un-metered water are used, which have to be estimated (in fire fighting, for example). Where domestic water is not metered, much more of the volume of water actually consumed has to be estimated.

3.1.2 Definitions and Significance of Terms

The term "unaccounted-for water" (UFW) is as defined above, being the difference between "net production" (the volume of water delivered into a network) and "consumption" (the volume of water that can be accounted for by legitimate consumption, metered and un-metered). The definition is straightforward, but determining a real, accurate value can be very difficult. This difficulty is not however a reason not to start a UFW control programme.

(1) Net Production

The volume of water delivered into the distribution network should be accurately metered, though meters are often not installed, unserviceable, or markedly inaccurate. Inaccuracies of the same order of magnitude (or higher) are probable if production volumes are estimated from nominal pump capacities combined with hours run data.

(2) Consumption

Where all domestic, industrial, and commercial consumption is metered, the quantity of accounted-for water must include an estimate of legitimate un-metered public supplies, such as those used for fire fighting, mains flushing, public standpipes, and toilets. To put it as an equation,

total consumption = metered consumption + estimated consumption (for all private and public purposes.)

Sample test metering will probably be necessary to obtain reliable estimates. Metering is essential for large government offices or military establishments, even when no charges are levied. Where domestic consumption is not metered, it has to be estimated by a sample household study, which will require a special programme to be repeated periodically.

(3) Physical and Non-Physical Losses

UFW calculated from the difference between production and consumption falls into two categories, designated by the terms:

(a) "Non-physical losses" Water used but not recorded by consumer's meters or otherwise accounted for, estimated & assessed by government or other public use. It includes water consumed through illegal connections.

(b) "Physical Losses" Water lost through leakage, both on the water supply utility network and facilities and on customers' service pipes. This is a resource loss and is reflected in the cost of production.

The significance of each category varies enormously in different countries and even in different water systems in the same country.

(4) Waste of Water

Other losses arise from wastage by the consumer. They may arise either from wasteful use or from defective fittings. In a fully metered system it is often assumed that such losses have no impact on revenue and are excluded from estimates of UFW. This assumption is not justified because the loss is frequently not recorded on the consumer's meter.

(5) Raw Water (Non net production)

Raw water supply is the total amount of untreated water taken from sources such as a river or boreholes. When raw water is taken from a source, losses occur during storage, transmission, treatment, and treated water storage (apart from normal, acceptable use in the production process). Such losses can occur from leakage, overflow, or inefficient treatment plant operation.

These losses are excluded from UFW but can be of equal importance and require investigation by management at the same time.

3.1.3 Calculating UFW

UFW is often given in terms of a percentage of net production. When expressed in this way, quoted figures must be treated with caution. However, since percentage figures are the standard form of expression, they are used here.

It is good practice when using percentages to also quote either the net production volumes or the amount of UFW in volumetric terms.

Thus:

UFW = Net Production - Total assessed legal water use (m3/day)

UFW Ratio = UFW Volume / Net production volume (%)

The UFW ratio may sometimes be expressed as "Network Efficiency", which is:

Network efficiency = 100% - UFW ratio %