CHAPTER 4

PLANNING FUNDAMENTALS AND STRATEGY

CHAPTER 4 PLANNING FUNDAMENTALS AND STRATEGY

The aim of this Chapter is to outline the sector policy, state sector priorities and goals, present the planning process to meet sector goals and finally to outline the strategies proposed. A substantial portion of this Chapter is devoted to the principles of planning.

Sector Policy

As discussed in Chapter 3, it becomes the main role of YCDC to provide water to City population entirely. However, due to various reasons, this institution has been able to provide water of variable quantity and quality only to 37% of the City population. As a result, a large number of players are involved in current water supply activities. The status of overall water supply goal for the City therefore depends on the extent to which both YCDC as well as other players are able to improve their supply.

The main objective of the current project is to strength the role of YCDC so that it could provide water to the majority of the City population.

Having said above, it is suggested that in the medium to long-term, YCDC develop its capacity not overall capability to coordinate work of all players involved only to provide water for much of the City population from its own facilities but also enhance its.

Sector Priorities And Goals

As discussed in earlier Chapters, the current City water supply system owned by YCDC is characterized as follows,

- A large number of users with a variable pattern of use
- Making use of several sub-systems
- A variety of supply facilities of different age
- Water is provided to 26 of the 33 townships with a vast variation in supply conditions among them

Any improvements plan will obviously have to work on all different aspects of the current system listed above. Mainly due to resource constraints and other reasons, it is not possible to focus concurrently on all of the above aspects by the current project. This leads to the selection of priorities for further planning. The overall sector priorities of the Master Plan are summarized in Table 4.1.

Working along the above priorities, the Master Plan has established six main goals for achievement by its target year of 2020 as listed below:

- Customer access to water from the current 37% service ratio will be increased to 70%.
- Current Leakage ratio (50 %) will be reduced to 25 % as a goal.
- Townships served with supply increased from current 26 to all (33) townships .
- Two new WTP (Water Treatment Plant) construction (One for river water and the other for reservoir water).
- Service condition in terms of supply pressure and duration will be improved by zoning system.
- Staff capability for planning, monitoring and implementation will have enhanced

Table 4.1 Sector Priorities

Component	Priority
Township	33 Township with different service ratio
Supply sub-system	Pipe system
Method of supply	Individual connections with meter
Water Source and Treatment	Develop surface water source and reduce exiting tube well numbers. Supply priority is surface water in central block. Two new Water Treatment plants will be constructed to assure the water quality.
Existing Facilities	Rehabilitate aged pipes and facilities Unnecessary facilities under the new supply concept (zoning system) are abandoned.
Industrial Zones	Start to supply YCDC water

4.1 POPULATION DENSITY

Table 4.2 shows population density by township.

Table 4.2 Population Density (persons/ha)

	Township	Density			Area in 2000 (ha)
		In 1983 [1]	in 1991 [2]	in 2000 [3]	
1	Ahlone	200	153	170.3	269
2	Bahan	116	98	113.3	884
3	Botataung	190	186	232.7	238
4	Dagon	69	66	90.1	467
5	Dagon Myothit (East)	-	31	9.7	6,005
6	Dagon Myothit (North)	-	-	40.7	2,627
7	Dagon Myothit (Seikkan)	-	-	5.0	3,850
8	Dagon Myothit (South)	-	-	40.6	3,638
9	Dala	52	62	28.7	2,831
10	Dawbon	138	163	227.8	368
11	Hlaing	133	130	129.0	1,370
12	Hlaingthaya	-	54	31.1	6,736
13	Insein	99	103	72.4	3,501
14	Kamayut	121	111	140.5	622
15	Kyauktada	726	758	716.7	65
16	Kyeemyindaing	135	150	164.7	559
17	Lanmadaw	322	307	303.9	141

18	Latha	400	414	421.2	81
19	Mayangone	59	61	76.1	2,533
20	Mingalardon	37	48	15.6	11,504
21	Mingalartaungnyunt	213	219	228.3	506
22	North Okkalapa	147	173	107.7	2,826
23	Pabedan	809	839	658.5	76
24	Pazundaung	375	336	398.9	101
25	Sanchaung	266	260	335.4	247
26	Seikan	46	14	12.7	114
27	Seikkyi Kanaungto	27	32	46.0	585
28	Shwepyitha	-	52	46.1	3,939
29	South Okkalapa	177	184	301.1	770
30	Tamwe	231	250	270.7	500
31	Thaketa	149	168	226.4	1,301
32	Thingangyun	170	186	220.1	1,150
33	Yankin	160	155	224.4	503
	Total			63.8	60,909

1,2 ; source:Yangon infrastruture and environmental services, pre-feasibility study, final report, 1993
3 ; estimated by JICA Study Team

The relatively high density is in downtown areas, namely four (4) townships (Kyauktada, Pabedan, Lath, Pazundaung), have seemed to be saturated and the average population density for the four townships is 529 persons/ha. Thus, the saturated population density for the planning purpose is set at 529 persons/ha. The Figure 4.1 shows population density in 2000 by township, which indicates the variation within the study area.

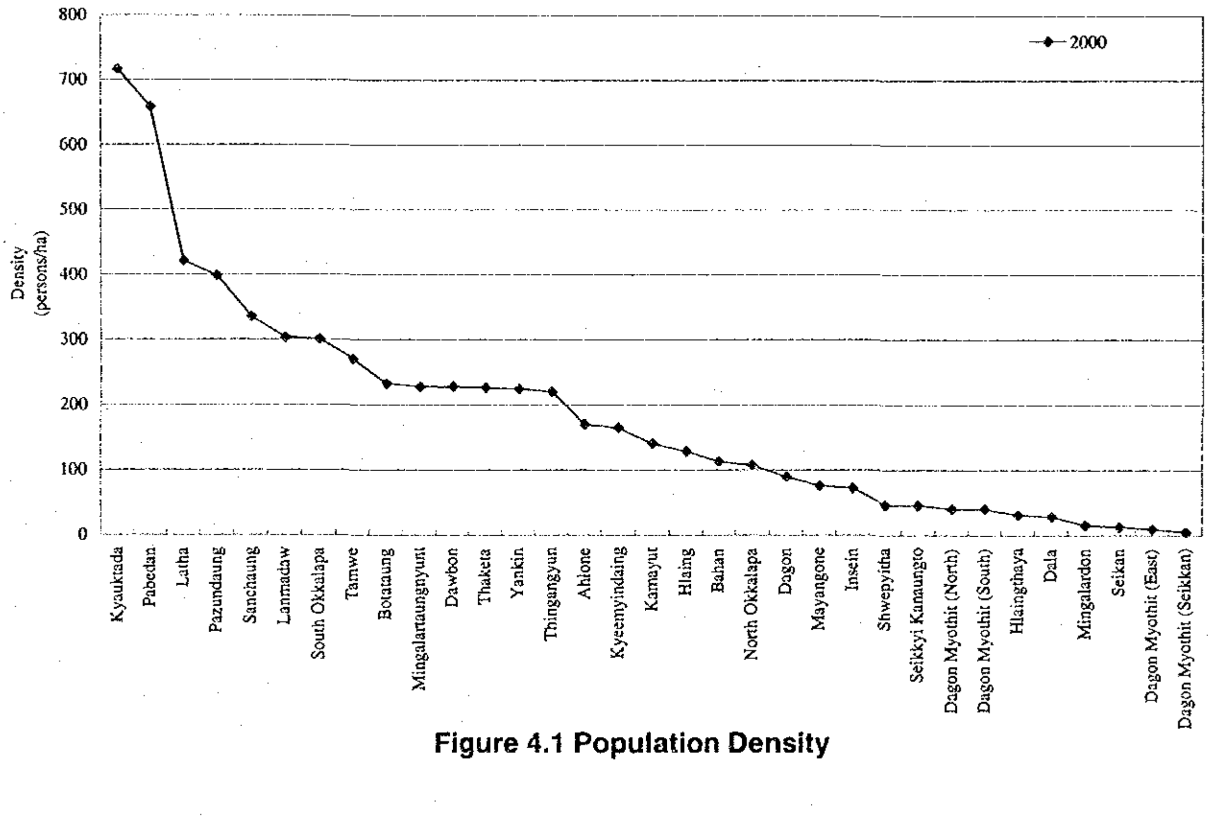


Figure 4.1 Population Density

4.2 LAND USE

The current land use is shown in Table 4.3 and residential area's details (High, Middle, and Low class residential area) are shown Table 4.4.

Table 4.3 Land Use Category By Township (%)

No	Township	Res.	Gov.	Com. & Ind.	Farm	Other	Total
1	Ahlone	49	47	0	0	4	100
2	Bahan	78	9	1	0	12	100
3	Botataung	30	69	1	0	0	100
4	Dagon	19	64	3	0	14	100
5	Dagon Myothit (East)	11	2	0	40	47	100
6	Dagon Myothit (North)	75	11	1	0	13	100
7	Dagon Myothit (Seikkan)	9	1	8	19	63	100
8	Dagon Myothit (South)	57	12	8	22	1	100
9	Dala	29	4	0	67	0	100
10	Dawbon	68	21	0	0	11	100
11	Hlaing	67	21	1	0	11	100
12	Hlaingthaya	31	1	11	57	0	100
13	Insein	47	27	2	0	24	100
14	Kamayut	46	14	0	0	40	100
15	Kyauktada	60	29	2	0	9	100
16	Kyeemyindaing	39	7	1	0	53	100
17	Lanmadaw	60	35	1	0	4	100
18	Latha	46	43	6	0	5	100
19	Mayangone	49	19	7	0	25	100
20	Mingalardon	21	48	9	9	13	100
21	Mingalartaungnyunt	28	11	15	0	46	100
22	North Okkalapa	39	4	4	26	27	100
23	Pabedan	62	21	16	0	1	100
24	Pazundaung	77	10	1	0	12	100
25	Sanchaung	64	7	1	0	28	100
26	Seikan	0	99	0	0	1	100
27	Seikkyi Kanaungto	10	0	0	89	1	100
28	Shwepyitha	56	24	4	16	0	100
29	South Okkalapa	89	0	1	0	10	100
30	Tamwe	63	25	4	0	8	100
31	Thaketa	69	20	0	0	11	100
32	Thingangyun	77	11	0	0	12	100
33	Yankin	62	32	0	0	6	100
	Total	37	19	5	22	17	100

Note : JICA Study Team estimation based on YCDC data.

4.3 HOUSING DEVELOPMENT PLAN

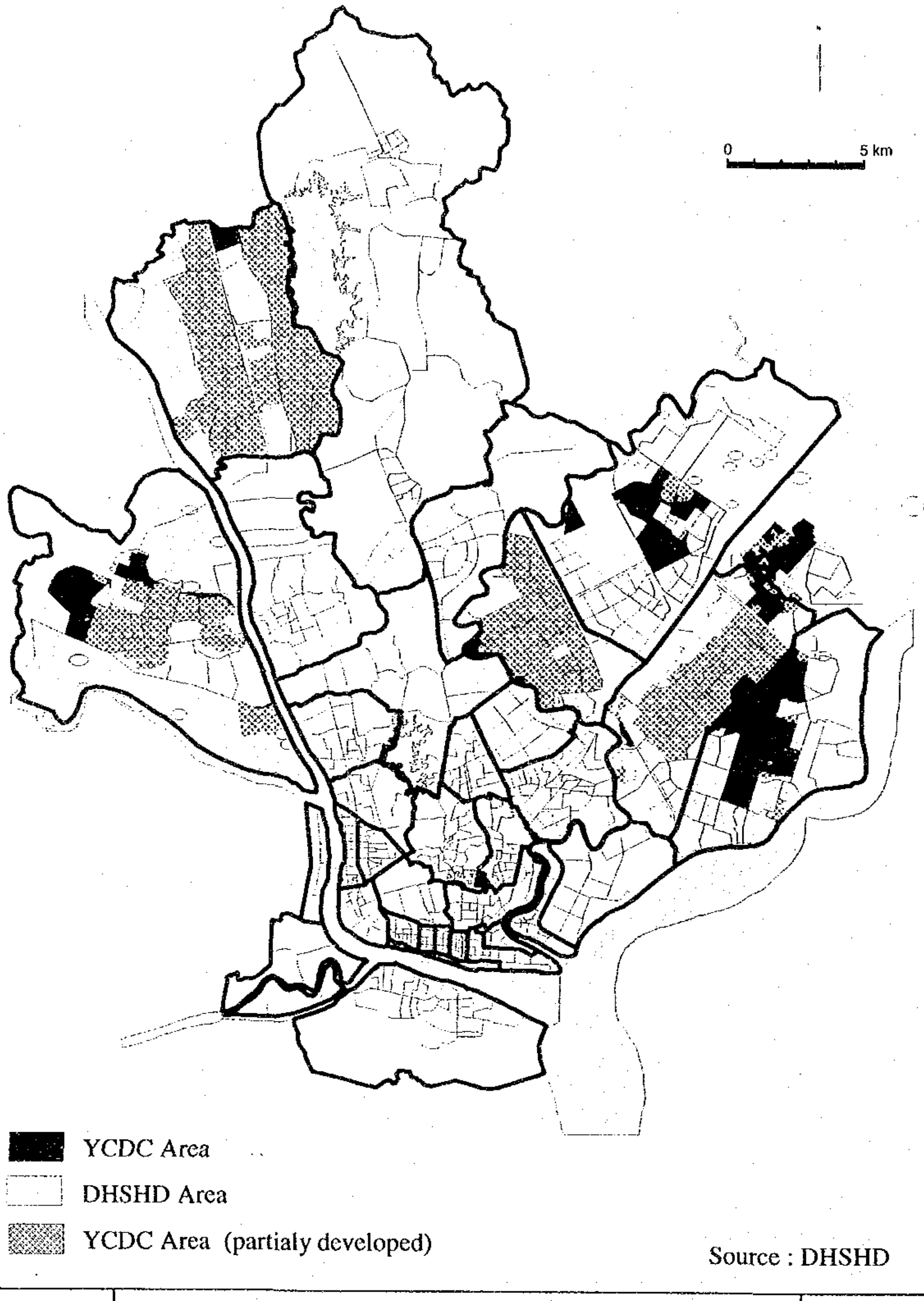
The housing development was planned and developed mainly by DHSHD (Development of Human and Housing Development) in the Study Area so far. After 1990, the part of housing

Table 4.4 Residential Area by Housing Class (%)

No	Township	Total Residential Area	High	Middle	Low
1	Ahlone	49	4	44	0
2	Bahan	78	53	19	5
3	Botataung	30	2	28	0
4	Dagon	19	10	9	0
5	Dagon Myothit (East)	11	2	4	5
6	Dagon Myothit (North)	75	0	54	21
7	Dagon Myothit (Seikkan)	9	0	2	7
8	Dagon Myothit (South)	57	0	34	23
9	Dala	29	0	1	28
10	Dawbon	68	0	5	63
11	Hlaing	67	15	39	12
12	Hlaingthaya	31	5	0	25
13	Insein	47	8	18	20
14	Kamayut	46	22	20	4
15	Kyauktada	60	0	60	0
16	Kyeemyindaing	39	0	22	17
17	Lanmadaw	60	0	60	0
18	Latha	46	0	46	0
19	Mayangone	49	42	3	3
20	Mingalardon	21	5	11	4
21	Mingalartaungnyunt	28	13	13	1
22	North Okkalapa	39	9	6	24
23	Pabedan	62	0	62	0
24	Pazundaung	77	16	30	31
25	Sanchaung	64	21	27	17
26	Seikan	0	0	0	0
27	Seikkyi Kanaungto	10	0	0	10
28	Shwepyitha	56	7	16	33
29	South Okkalapa	89	3	82	4
30	Tamwe	63	7	55	2
31	Thaketa	69	8	50	11
32	Thingangyun	77	14	6	57
33	Yankin	62	36	18	8
	Total	37	7	14	16

Source: YCDC

development was transferred to YCDC. The transfer is expected to be more in future. Currently, it can be said that the housing development is carried out by both YCDC and DHSHD cooperatively. It is expected that YCDC's role in housing development would increase in future. The Large housing development is planned in Dagon Myothit (East, North, South, Seikkan), Hlaingthaya, Schwepyitha (6 townships) as can be seen in the Figure 4.2. These areas are considered as development areas in this Master Plan. Some portions of the planned housing area are currently used as agricultural land. In future, population increase will occur in those areas.



THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR

Housing Development Plan

FIG 4.2

4.4 POPULATION DISTRIBUTION

The total population as forecasted in section 2.6 is shown below.

Table 4.5 Future Populations

(Persons)

Year	Population
2000	3,887,000
2005	4,403,000
2010	4,955,000
2015	5,541,000
2020	6,159,000

It is necessary to distribute the above population estimates by township in order to plan for the improvements needed. In order to distribute the total population into each township, the following criteria are considered.

- Past population growth rate in each township
- Possibility of development area (housing plan, etc)
- Population Density (the saturated density is set as 529 persons/ha)

The following Table summarizes the characteristics of each township and GR(growth rate) for planning.

Table 4.6 Township Characteristics

No	Township	Development Possibility	Density Person/ha	GR (73-83)	GR (83-98)	GR (73-98)	GR for Plan	Remarks
1	Ahlone	Low	170.3	1.08%	-1.15%	-0.26%	1.08%	
2	Bahan	Low	113.3	1.76%	-0.47%	0.42%	0.42%	
3	Botataung	Low	232.7	1.10%	0.46%	0.72%	0.72%	
4	Dagon	Low	90.1	-0.06%	0.79%	0.45%	0.45%	
5	Dagon Myothit (East)	High	9.7				*	Will be developed
6	Dagon Myothit (North)	Middle	40.7				*	〃
7	Dagon Myothit (Seikkan)	High	5.0				*	〃
8	Dagon Myothit (South)	High	40.6				*	〃
9	Dala	High	28.7	2.22%	2.39%	2.32%	2.32%	
10	Dawbon	Low	227.8	2.93%	3.15%	3.06%	3.06%	
11	Hlaing	Low	129.0	2.70%	-0.15%	0.98%	0.98%	
12	Hlaingthaya	High	31.1				*	Will be developed
13	Insein	Middle	72.4	3.20%	1.35%	2.09%	2.09%	
14	Kamayut	Low	140.5	1.11%	0.66%	0.84%	0.84%	
15	Kyauktada	Low	716.7	-0.04%	1.06%	0.62%	0.62%	
16	Kyeemyindaing	Low	164.7	0.86%	1.51%	1.25%	1.25%	
17	Lanmadaw	Low	303.9	-0.24%	-0.17%	-0.20%	0.00%	Same as current situation

18	Latha	Low	421.2	-0.19%	0.31%	0.11%	0.11%	
19	Mayangone	Low	76.1	3.45%	1.22%	2.10%	2.10%	
20	Mingalardon	High	15.6	2.96%	3.09%	3.04%	3.04%	
21	Mingalartaungnyunt	Low	228.3	1.38%	-0.04%	0.53%	0.53%	
22	North Okkalapa	Middle	107.7	2.09%	2.80%	2.52%	2.52%	
23	Pabedan	Low	658.5	0.29%	0.83%	0.61%	0.61%	
24	Pazundaung	Low	398.9	1.11%	-0.08%	0.39%	0.39%	
25	Sanchaung	Low	335.4	0.34%	0.90%	0.67%	0.67%	
26	Seikan	Low	12.7	-3.73%	-8.57%	-6.66%	0.00%	Same as current situation
27	Seikkyi Kanaungto	High	46.0	2.14%	3.45%	2.92%	2.92%	
28	Shwepyitha	High	46.1				*	Will be developed
29	South Okkalapa	Low	301.1	2.06%	1.23%	1.56%	1.56%	
30	Tamwe	Low	270.7	1.18%	0.46%	0.75%	0.75%	
31	Thaketa	Low	226.4	2.84%	2.51%	2.64%	2.64%	
32	Thingangyun	Low	220.1	3.23%	1.44%	2.15%	2.15%	
33	Yankin	Low	224.4	1.85%	1.75%	1.79%	1.79%	

Note) GR: Growth Rate

Considering the above three (3) criteria, the future population is estimated for each township (Table 4.7).

Table 4.7 Future Populations by Township

(Persons)

Township	Pop. in 2000	Pop in 2005	Pop. in 2010	Pop. in 2015	Pop. in 2020
Ahlone	45,870	48,412	51,095	53,927	56,916
Bahan	100,139	102,235	104,375	106,559	108,789
Botataung	55,434	57,446	59,531	61,691	63,930
Dagon	42,079	43,029	44,000	44,993	46,009
Dagon Myothit (East)	58,108	76,871	95,921	114,768	132,879
Dagon Myothit (North)	107,045	141,610	176,703	211,422	244,785
Dagon Myothit (Seikkan)	19,245	25,460	31,770	38,012	44,010
Dagon Myothit (South)	147,804	195,531	243,987	291,927	337,994
Dala	81,317	91,210	102,306	114,752	128,712
Dawbon	83,787	97,426	113,285	131,726	153,169
Hlaing	176,751	185,575	194,840	204,567	214,780
Hlaingthaya	209,714	277,432	346,184	414,204	479,566
Insein	253,421	280,992	311,562	345,458	383,042
Kamayut	87,325	91,050	94,934	98,984	103,206
Kyauktada	46,405	46,405	46,405	46,405	46,405
Kyeemyindaing	92,113	98,012	104,289	110,968	118,075
Lanmadaw	42,742	42,742	42,742	42,742	42,742
Latha	34,254	34,444	34,635	34,827	35,021
Mayangone	192,694	213,838	237,302	263,341	292,237
Mingalardon	179,982	209,049	242,811	282,025	327,572
Mingalartaungnyunt	115,597	118,673	121,830	125,071	128,399
North Okkalapa	304,339	344,625	390,243	441,900	500,395

Pabedan	49,969	49,969	49,969	49,969	49,969
Pazundaung	40,390	41,194	42,014	42,850	43,703
Sanchaung	82,951	85,788	88,722	91,757	94,895
Seikan	1,452	1,452	1,452	1,452	1,452
Seikkyi Kanaungto	26,938	31,108	35,924	41,485	47,907
Shwepyitha	181,484	240,086	299,583	358,447	415,011
South Okkalapa	231,849	250,553	270,765	292,608	316,213
Tamwe	135,242	140,360	145,672	151,185	156,906
Thaketa	294,582	335,561	382,241	435,414	495,984
Thingangyun	253,119	281,543	313,159	348,326	387,442
Yankin	112,859	123,319	134,749	147,238	160,885
Total	3,887,000	4,403,000	4,955,000	5,541,000	6,159,000

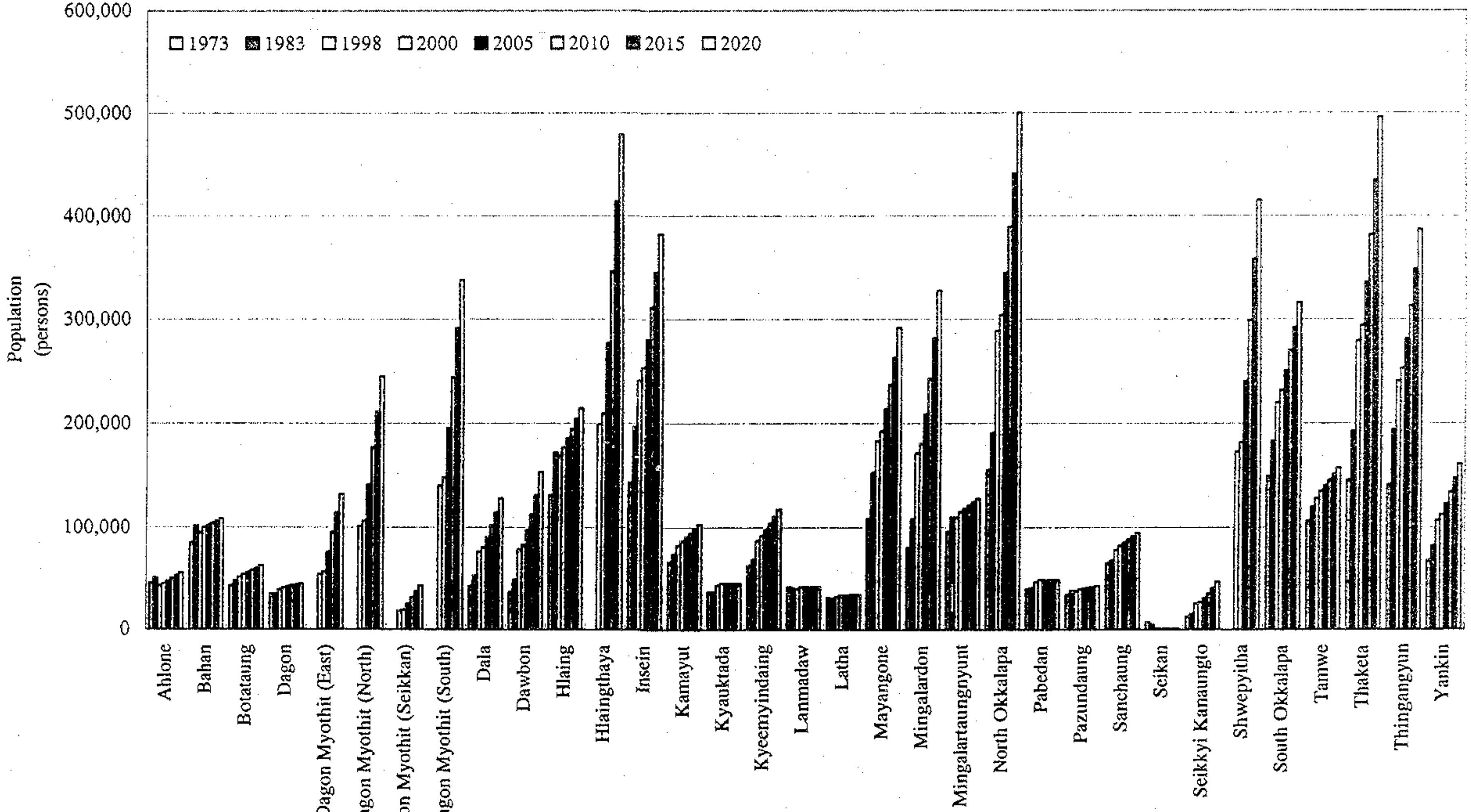
Table 4.8 shows growth rate and population density of each township.

Figure 4.3 shows population trends for each township and population in 2000 and 2020 are shown in figure 4.4.

Table 4.8 Future Populations by Township and Growth Rate

No.	Township	Population (persons)					Growth Rate (%)				Pop Density (persons/ha)				
		2000	2005	2010	2015	2020	(2000-2005)	(2005-2010)	(2010-2015)	(2015-2020)	2000	2005	2010	2015	2020
1	Ahlone	45,870	48,412	51,095	53,927	56,916	1.08%	1.08%	1.08%	1.08%	170	180	190	200	211
2	Bahan	100,139	102,235	104,375	106,559	108,789	0.42%	0.42%	0.42%	0.42%	113	116	118	121	123
3	Botataung	55,434	57,446	59,531	61,691	63,930	0.72%	0.72%	0.72%	0.72%	233	241	250	259	268
4	Dagon	42,079	43,029	44,000	44,993	46,009	0.45%	0.45%	0.45%	0.45%	90	92	94	96	98
5	Dagon Myothit (East)	58,108	76,871	95,921	114,768	132,879	5.76%	4.53%	3.65%	2.97%	10	13	16	19	22
6	Dagon Myothit (North)	107,045	141,610	176,703	211,422	244,785	5.76%	4.53%	3.65%	2.97%	41	54	67	80	93
7	Dagon Myothit (Seikkan)	19,245	25,460	31,770	38,012	44,010	5.76%	4.53%	3.65%	2.97%	5	7	8	10	11
8	Dagon Myothit (South)	147,804	195,531	243,987	291,927	337,994	5.76%	4.53%	3.65%	2.97%	41	54	67	80	93
9	Dala	81,317	91,210	102,306	114,752	128,712	2.32%	2.32%	2.32%	2.32%	29	32	36	41	45
10	Dawbon	83,787	97,426	113,285	131,726	153,169	3.06%	3.06%	3.06%	3.06%	228	265	308	358	416
11	Hlaing	176,751	185,575	194,840	204,567	214,780	0.98%	0.98%	0.98%	0.98%	129	135	142	149	157
12	Hlaingthaya	209,714	277,432	346,184	414,204	479,566	5.76%	4.53%	3.65%	2.97%	31	41	51	61	71
13	Insein	253,421	280,992	311,562	345,458	383,042	2.09%	2.09%	2.09%	2.09%	72	80	89	99	109
14	Kamayut	87,325	91,050	94,934	98,984	103,206	0.84%	0.84%	0.84%	0.84%	140	146	153	159	166
15	Kyauktada	46,405	46,405	46,405	46,405	46,405	0.00%	0.00%	0.00%	0.00%	717	717	717	717	717
16	Kyeemyindaing	92,113	98,012	104,289	110,968	118,075	1.25%	1.25%	1.25%	1.25%	165	175	186	198	211
17	Lanmadaw	42,742	42,742	42,742	42,742	42,742	0.00%	0.00%	0.00%	0.00%	304	304	304	304	304
18	Latha	34,254	34,444	34,635	34,827	35,021	0.11%	0.11%	0.11%	0.11%	421	424	426	428	431
19	Mayangone	192,694	213,838	237,302	263,341	292,237	2.10%	2.10%	2.10%	2.10%	76	84	94	104	115
20	Mingalardon	179,982	209,049	242,811	282,025	327,572	3.04%	3.04%	3.04%	3.04%	16	18	21	25	28
21	Mingalartaungnyunt	115,597	118,673	121,830	125,071	128,399	0.53%	0.53%	0.53%	0.53%	228	234	241	247	254
22	North Okkalapa	304,339	344,625	390,243	441,900	500,395	2.52%	2.52%	2.52%	2.52%	108	122	138	156	177
23	Pabedan	49,969	49,969	49,969	49,969	49,969	0.00%	0.00%	0.00%	0.00%	659	659	659	659	659
24	Pazundaung	40,390	41,194	42,014	42,850	43,703	0.39%	0.39%	0.39%	0.40%	399	407	415	423	432
25	Sanchaung	82,951	85,788	88,722	91,757	94,895	0.67%	0.67%	0.67%	0.67%	335	347	359	371	384
26	Seikan	1,452	1,452	1,452	1,452	1,452	0.00%	0.00%	0.00%	0.00%	13	13	13	13	13
27	Seikkyi Kanaungto	26,938	31,108	35,924	41,485	47,907	2.92%	2.92%	2.92%	2.92%	46	53	61	71	82
28	Shwepyitha	181,484	240,086	299,583	358,447	415,011	5.76%	4.53%	3.65%	2.97%	46	61	76	91	105
29	South Okkalapa	231,849	250,553	270,765	292,608	316,213	1.56%	1.56%	1.56%	1.56%	301	325	352	380	411
30	Tamwe	135,242	140,360	145,672	151,185	156,906	0.75%	0.75%	0.75%	0.75%	271	281	292	303	314
31	Thaketa	294,582	335,561	382,241	435,414	495,984	2.64%	2.64%	2.64%	2.64%	226	258	294	335	381
32	Thingangyun	253,119	281,543	313,159	348,326	387,442	2.15%	2.15%	2.15%	2.15%	220	245	272	303	337
33	Yankin	112,859	123,319	134,749	147,238	160,885	1.79%	1.79%	1.79%	1.79%	224	245	268	293	320
	Total	3,887,000	4,403,000	4,955,000	5,541,000	6,159,000	2.52%	2.39%	2.26%	2.14%	64	72	81	91	101

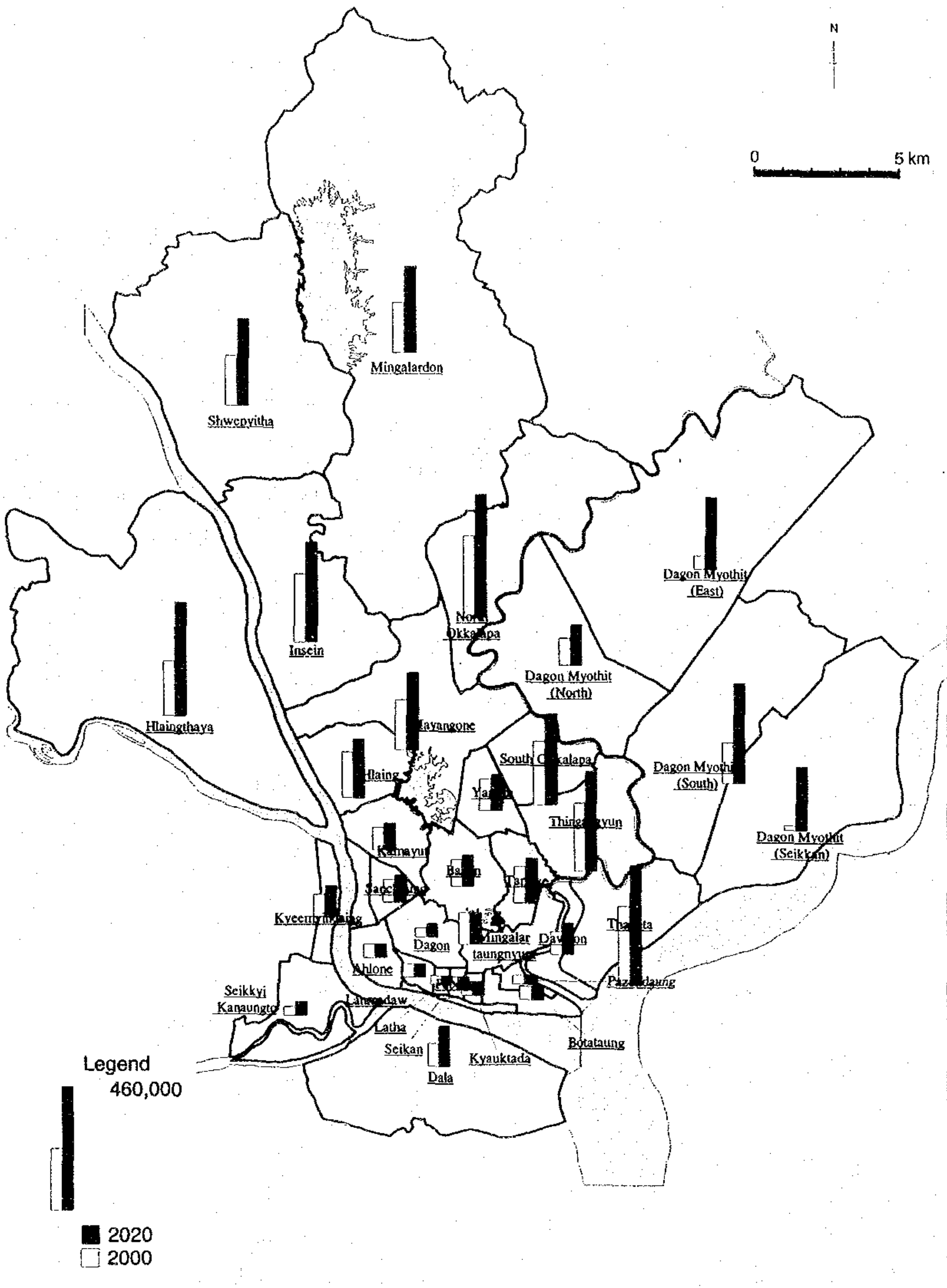
4 - 10



THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR

FIG 4.3

Population Trend By Township



THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR

FIG 4.4

Population in 2000 and 2020

4.5 WATER CONSUMPTION

In this section, current water consumption and future demand are analyzed. The analysis is based on for 2000 provided by YCDC.

4.5.1 Water Consumption (2000)

(1) Water Tariff

The current water tariff has 3 categories, namely, Domestic, Department, Commercial&Industry, Which is shown in Table 4.9. The bills are issued to un-metered domestic and commercial & industry customers each quarter. Water meter is read every month and the bills are issued every month. The un-metered department customers are issued bills once a year. It is YCDC policy to collect water charges from all types of customers except from these who enjoy free water (monastery etc).

Table 4.9 Water Tariff Rate

		Domestic	Dept.	Com.&Ind.	Others
Metered	(Kyats/1000 gallon)	30	20	135	-
	(Kyats/m^3)	6.60	4.40	29.70	-
Un-Metered	(Kyats/bill/month)	120	-	-	202

Source:YCDC

The total number of metered and un-metered customers as of 1st quarter of 2001 is summarized in Table 4.10. The total number of connections is 112,315 of which only 23 % (25,652 connections) are metered.

Table 4.10 Number of Metered and Un-metered Connections

	Domestic	Dept.	Com.&Ind.	Total
Metered	22,612	101	2,939	25,652
Unmetered	82,020	1,171	3,472	86,663
Total	104,632	1,272	6,411	112,315

Source:YCDC Head Quarter

In the year of 2000, the a total revenue of 308 million Kyats has been collected (84 million Kyats from metered customers and 224 million Kyats from un-metered customers).

(2) Domestic Water Consumption

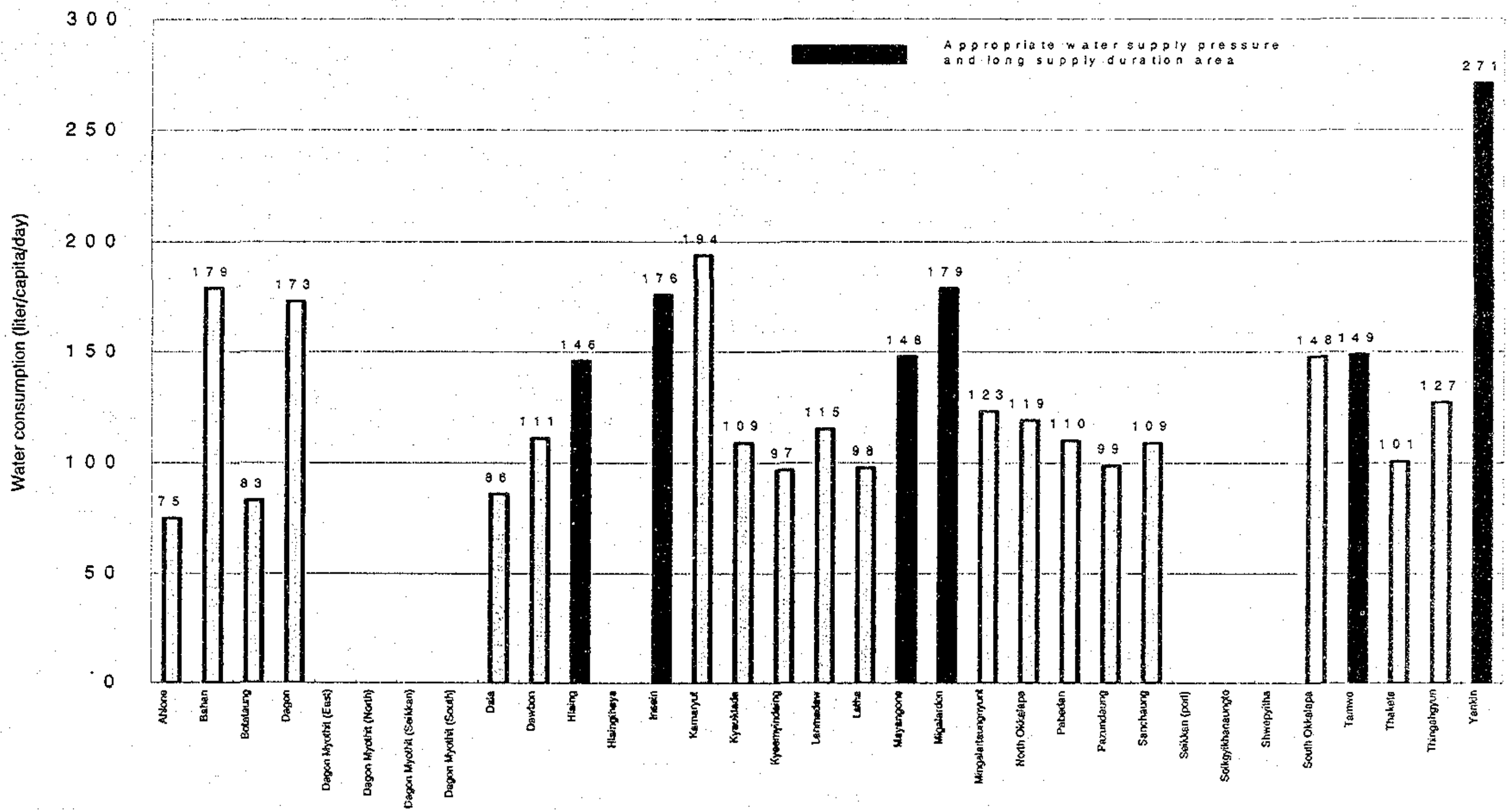
1) Metered

According to YCDC data, the total metered domestic consumption is 5,648,000 m^3/year in 2000. Table 4.11 and Figure 4.5 show the estimated per capita consumption by township, which is calculated from metered consumption (7 persons /household is assumed). The highest is 271 lpcd (l/capita/day) in Yankin and the lowest is 75 lpcd in Ahlone.

Table 4.11 Metered Water Consumption in 2000

No.	Township	Estimated average per capita consumption	Service Ratio of YCDC Piped Water	Supply Duration	Water Pressure
		(lpcd)	(%)	(hr per day)	
1	Ahlone	75	26	10	X
2	Bahan	179	91	15	O
3	Botataung	83	88	24-10	X
4	Dagon	173	97	8	X
5	Dagon Myothit (East)		0	-	-
6	Dagon Myothit (North)		0	-	-
7	Dagon Myothit (Seikkan)		0	-	-
8	Dagon Myothit (South)		0	6	-
9	Dala	86	12	6	-
10	Dawbon	111	2	24-16	X
11	Hlaing	146	10	24	O
12	Hlaingthaya		0	4	-
13	Insein	176	10	24-2	O
14	Kamaryut	194	47	12	X
15	Kyauktada	109	100	24	X
16	Kyeemyindaing	97	20	6	X
17	Lanmadaw	115	97	24	X
18	Latha	98	100	24	X
19	Mayangone	148	67	24-14	O
20	Migalardon	179	20	24	O
21	Mingalartaungnyunt	123	99	24	X
22	North Okkalapa	119	66	24-8	X
23	Pabedan	110	100	24-15	-
24	Pazundaung	99	100	24	x
25	Sanchaung	109	40	5-1	x
26	Seikkan (port)		20	-	
27	Seikgyikhanaungto		0	-	
28	Shwepyitha		0	4	
29	South Okkalapa	148	68	24-10	x
30	Tamwe	149	92	24	o
31	Thaketa	101	14	24-8	-
32	Thingahgyun	127	7	24-8	x
33	Yankin	271	59	24-18	o

Note) Water pressure : "o"; Appropriate water supply pressure,
"x"; Low or negative water supply pressure,
"-"; No measurement or no water supply system



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Estimated Per Capita Domestic Consumption By Township

FIG 4.5

The average lpcd for relatively better condition's townships in term of pressure and supply duration (Hlaing, Insein, Mayangone, Mingaladon, Tamwe, Yankin see Figure 4.5 or Table 4.10) is about 180 lpcd.

2) Un-metered

The un-metered water consumption is estimated as 25,340,000 m3/year in 2000, using the number of bills issued, estimated per capita consumption, and average household size (7 person/household). Table 4.12 shows the results.

Table 4.12 Distribution of Un-metered Water Consumption in 2000

	Township	Total number of un-metered bills issued	Estimated average per capita consumption	Total un-metered water consumption
		(No./year)	(L/day/cap.)	(m3/year)
1	Ahlone	8,237	75	394,604
2	Bahan	12,011	179	1,373,293
3	Botataung	15,341	83	813,322
4	Dagon	5,966	173	659,265
5	Dagon Myothit (East)			
6	Dagon Myothit (North)			
7	Dagon Myothit (Seikkan)			
8	Dagon Myothit (South)			
9	Dala		86	
10	Dawbon	311	111	22,050
11	Hlaing	4,977	146	464,143
12	Hlaingthaya			
13	Insein	816	176	91,735
14	Kamaryut	3,228	194	400,006
15	Kyauktada	22,640	109	1,576,282
16	Kyeemyindaing	7,571	97	469,090
17	Lanmadaw	18,996	115	1,395,375
18	Latha	15,298	98	957,617
19	Mayangone	4,768	148	450,743
20	Migalardon	620	179	70,888
21	Mingalartaungnyunt	34,568	123	2,715,878
22	North Okkalapa	22,097	119	1,679,621
23	Pabedan	20,993	110	1,475,021
24	Pazundaung	16,979	99	1,073,688
25	Sanchaung		109	
26	Seikkan (port)			
27	Seikgyikhanaungto			
28	Shwepyitha			
29	South Okkalapa	15,544	148	1,469,452
30	Tamwe	45,025	149	4,285,198
31	Thaketa	8,096	101	522,303
32	Thingahgyun	3,522	127	285,709
33	Yankin	15,569	271	2,695,013
	Total	303,173		25,340,295

Total domestic consumption by both metered and un-metered customers in 2000 is summarized below.

Table 4.13 Total Domestic Water Consumption in 2000

	Number of issued bills	Domestic Water Consumption ($1000m^3$/year)	percapita consumption (lpcd)
metered	178,549/12	5,648	148
unmetered	303,173/ 4	(25,340)	131
Total	90,672	(31,988)	134

Note: The number in the parensesis is estimated one.

Figure 4.6 shows the monthly fluctuation of per capita consumption for the 6 townships and all township. The nominated township means 6 townships, at where the water supply condition is assumed better in terms of pressure and supply duration(see figure 4.5 for the 6 townships).

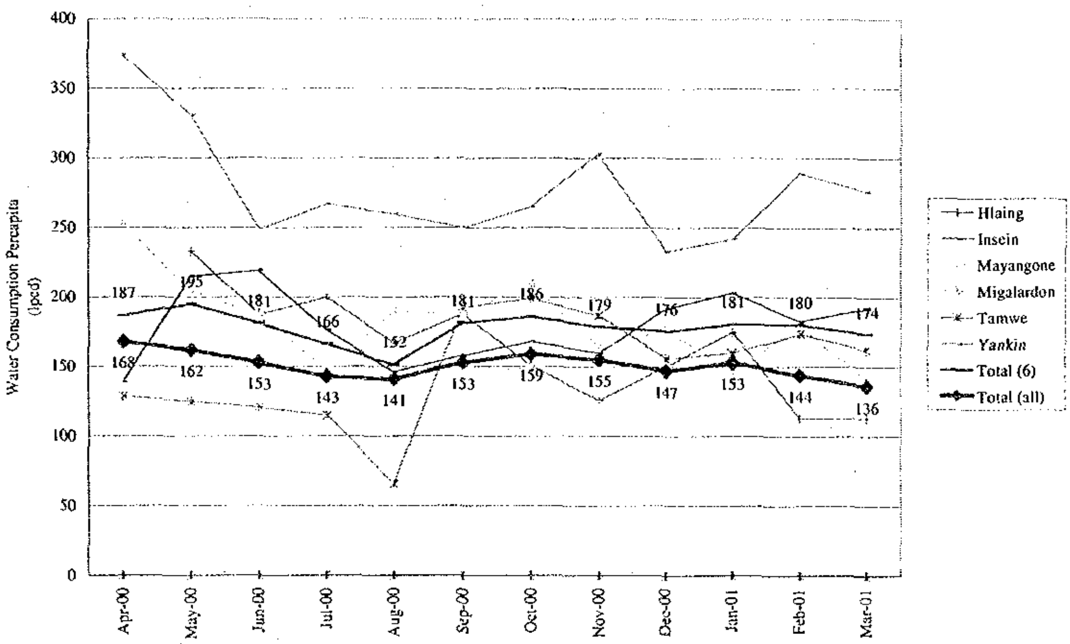


Figure 4.6 Monthly Consumption Pattern

From the figure, the followings are recognized,

- In April and May is relatively high use (187 lpcd in April, 195 lpcd in May):Dry Season
- In July and August is low use (166 lpcd in July, 152 lpcd in August): Rainy Season
- The yearly average is 178 lpcd for 6 township.

(3) Department Water Consumption

Metered to un-metered ratio is about 1:12 (very low metered rate). Since the water tariff (un-metered department is 4.4 kyats/m3 and un-metered bill amount in 2000 is 72,302,579 Kyats, un-metered customer's consumption is 16,432,000 m3/year (2000). The total consumption for department is about 16,965,000 m³/year in total.

Table 4.14 summarizes large consumers in Department category. This consumption rate will be used for future estimation.

Table 4.14 Large Consumers List in 2000

Township	Name	metered /unmetered	Average Water Consumption *	Average of Water Charge	Data
			(m^3/month)	(Kyats/month)	
Bahan	Directorate of industry	u	(13,636)	60,000	
Kyauktada	Strand Hotel	u	(7,855)	34,560	
Latha	Yangon General Hospital	u	(7,576)	33,333	
Mayangone	Inya Lake Hotel	u	(24,318)	107,000	
Mayangone	Paychiatric Hospital	u	(6,818)	30,000	
Mayangone	No.2 Hino Factory	u	(18,296)	80,501	
Mingalardon	Yangon airport	u	(45,818)	201,600	
Tamwe	General Worker's Hopital	u	(7,364)	32,400	
Tamwe	Kan Thar Yar Hospital	u	(7,364)	32,400	
Thaketa	Electric power station	m	11,005		Jul:Sep-00(Ave)
Yankin	Ministry Office: Industry (1)	m	17,385		Mar:May-00(Ave)
Yankin	Ministry of Mining	u	(6,818)	30,000	

Source: YCDC
*: The figure in the parenthesis is estimation from Water Charge

(4) Commercial & Industry Water Consumption
The estimated water consumption is as follows,

Metered : 1,486,000 m³/day (2000)
Un-metered: 1,115,000 m³/year (2000)
Total: 2,601,000 m³/year (2000)

The total water consumption of the above 2 users is estimated in Table 4.15.

Table 4.15 Water Consumption of Department, Comercial. & Industry in 2000

User	Rate	Bill amount (kyats/year)	Water Charge (kyats/m³)	Consumption (1000m³/year)
Department	Metered	2,343,655	4.40	533
	Un-metered	72,302,579	4.40	(16,432)
	Total	74,646,234		(16,965)
Commercial & Industry	Metered	44,135,695	29.70	1,486
	Un-metered	33,110,474	29.70	(1,115)
	Total	77,246,169		(2,601)

Source: YCDC
Note: The figures in the parenthesis are estimation from Water Charge

(5) Total Water Consumption

The total consumption of water by all Table 4.16 summarizes the estimated total water consumption in the year of 2000.

Table 4.16 Water Consumption in 2000

(1000m³/year)

	Domestic	Department	Com.& Ind.	Total
Metered	5,648	533	1,486	7,667
	(11%)	(1%)	(3%)	(15%)
Un-metered	25,340	16,432	1,115	42,888
	(50%)	(33%)	(2%)	(85%)
Total	30,988	16,965	2,601	50,554
	(61%)	(34%)	(5%)	(100%)
Ratio to Domestic	1.00	0.55 (0.07 except large user)	0.08	1.63

The above data indicate that the domestic water use is the highest (61 % of total) followed by Department use (34 %). Current usage by Commercial & Industry category is only 5 %.

(6) Comparison of Metered and Un-metered Water Consumption

Table 4.17 shows Metered and Un-metered water consumption in m³/month/bill.

Table 4.17 Comparison of Metered and Un-Metered Consumption

(m³/month/bill)

	Department	Commercial & Industrial
Metered Consumer (A)	1,102.8	57.0
	(483)	(26,063)
Un Metered Consumer (B)	1,127.1	26.9
	(1,215)	(13,812)
Conversion Factor (A/B)	0.98	2.12

( ):sample number (bill/year)

If we define the conversion factor as A/B (Metered Consumption/Un-Metered Consumption), this conversion factor tells followings,

- *For the Department, 0.98 of conversion factor means a reliable estimation for* un-metered use.
- On the other hand, 2.12.of conversion factor for Commercial & Industrial means under estimation for un-metered users. YCDC needs to reconsider the estimation way for these users.
- For the purpose of planning, this 2.12 conversion factor is used to estimate the demand.

4.5.2 Future Demand Estimation

Per Capita Consumption for the target year (2020) is set to 200 lpcd. So far, we knew 180 lpcd is the value for townships with better water availability (see section 4.5.1 (2)). On the other hands, consumer survey indicates a level of use of 222 lpcd. Thus, the mean value (180, 220) was decided to use for the planning.

The demand is also estimated by category , ie. Domestic, Department, Commercial & Industry, and Industrial Zones Demand.

For the domestic, per capita consumption applied for different years is ; 200 lpcd at 2020, 140 lpcd :2000:current , 150 lpcd:2005, 170 lpcd :2010, 190 lpcd :2015.

For the Department, the current ratio (except large users) to domestic (7 %) and the large users (see Table 4.13) is used.

For the Commercial & Industry, it is planned to use the current ratio to domestic (8%) and the conversion factor (2.12). Thus the 17 % of ratio to domestic is applied for future demand estimation.

For the Industrial Zone (7 existing and 2 planned), the water demand is estimated using built up ratio (using plot number in the Industry Zones) and consumer surveys result (average water use for a industry: 598 m3/month/company). Neat Table shows the results.

Table 4.18 Water Consumption of Industrial Zones

Zone Name	area	No. of plot			Start year	No.of work-ers	No.of operating plot					water consumption (m3/day)				
	ha	total	oper-ating	%			2000	2005	2010	2015	2020	2000	2005	2010	2015	2020
Shwepyitah	254	584	101	17.3%	1992	14432	101	164	227	290	354	2,013	3,269	4,525	5,781	7,056
Hlaingthayar	580	1,048	271	25.9%	1995	36543	271	543	814	1,048	1,048	5,402	10,824	16,226	20,890	20,890
Dagon South	157	2,019	737	36.5%	1992	11822	737	1,198	1,658	2,019	2,019	14,691	23,880	33,049	40,245	40,245
Dagon Seik-kan	334	432	22	5.1%	1996	3606	22	50	77	105	132	439	997	1,535	2,093	2,631
Mingaradon	90	39	2	5.1%	1995	-n.a	2	4	6	8	10	40	80	120	159	199
Shwe Pauk-kan	31	348	70	20.1%	1998	4205	70	245	348	348	348	1,395	4,884	6,937	6,937	6,937
Yangon	22	194	0	0.0%	2000		0	29	58	87	116	0	578	1,156	1,734	2,312
Sub total	1,468	4,664	1,203	25.8%		70608										
Planned																
east-dagon	200				2003		0	9	30	51	73	0	179	598	1,017	1,455
Shwehitha	161				2004		0	12	72	131	191	0	239	1,435	2,611	3,807

Source:DHSHD(Department of Human Settlement and Housing Development), JICA Study Team Consumer Survey

Table 4.19 shows estimated total demand.

Table 4.19 Estimated Demand

Year					2000	2005	2010	2015	2020
Total Population				(persons)	3,887,000	4,403,000	4,955,000	5,541,000	6,159,000
Service Ratio				(%)	37%	50%	60%	65%	70%
Served Population				(persons)	1,443,441	2,201,500	2,973,000	3,601,650	4,311,300
Daily Average Consumption	Domestic	percapita		(lpcd)	140	150	170	190	200
		Total	Consumption	(m3/day)	202,703	330,225	505,410	684,314	862,260
	Department	Total	Consumption	(m3/day)	46,480	63,838	76,101	88,624	101,080
	Commercial & Industry		Consumption	(m3/day)	7,123	56,138	85,920	116,333	146,584
		Industrial Zones	Consumption	(m3/day)	0	44,930	65,581	81,467	85,532
		Total	Consumption	(m3/day)	7,123	101,068	151,501	197,800	232,116
	Total			(m3/day)	256,306	495,131	733,012	970,738	1,195,456
Leakage	Ratio			(%)	50	45	40	35	25
	Amount			(m3/day)	256,306	405,107	488,675	522,705	398,485
Design Daily Average Demand				(m3/day)	512,612	900,238	1,221,687	1,493,443	1,593,941
Design Daily Average Demand per capita				(lpcd)	355	409	411	415	370
Design Daily Maximum Demand				(m3/day)	615,134	1,080,286	1,466,024	1,792,131	1,912,729
Design Daily Maximum Demand per capita				(lpcd)	426	491	493	498	444
Peak Factor					1.2	1.2	1.2	1.2	1.2

As can be seen in the above table, the following Planning Policies are set as the goals for this Master Plan. It is believed these goals, considering the existing conditions, are appropriate.

- 70 % of Service ratio is recommended at the target year, which is about twice as much as existing one (37 %).
- Current Leakage ratio is considered as 50 % which will be reduced to half (25 %) at the target year.
- As the result, the total Demand in the target year (2020) becomes 1,912,700 m3/day (420 MGD), which is about 3 times than the current demand (2000: 615,134 m3/day =135 MGD).

Current leakage ratio is estimated from the Leakage Survey. The model blocks survey results is as follows,

- **Insein**
  Pressure : 0.7 kgf/cm2
  Leakage: 13.3 %
  (Pipe Age 3)
- **Yankin**
  Pressure : 0.95 kgf/cm2
  Leakage: 58.8%
  (Pipe Age 30 years)
- **Tamwe**
  Pressure : 0.3 kgf/cm2
  Leakage: 20.8 %
  (Pipe Age 50 years)

Obviously, the leakage Ratio is highly related to its pressure and pipe age. Using model blocks data, we estimate the approximate function between pipe age and Leakage ratio under the condition of 10 m pressure. It is noted that leakage has to defined for a given value of pressure. The relationship (Figure 4.7) indicates the exiting situation as well as some useful suggestion for planning priority.

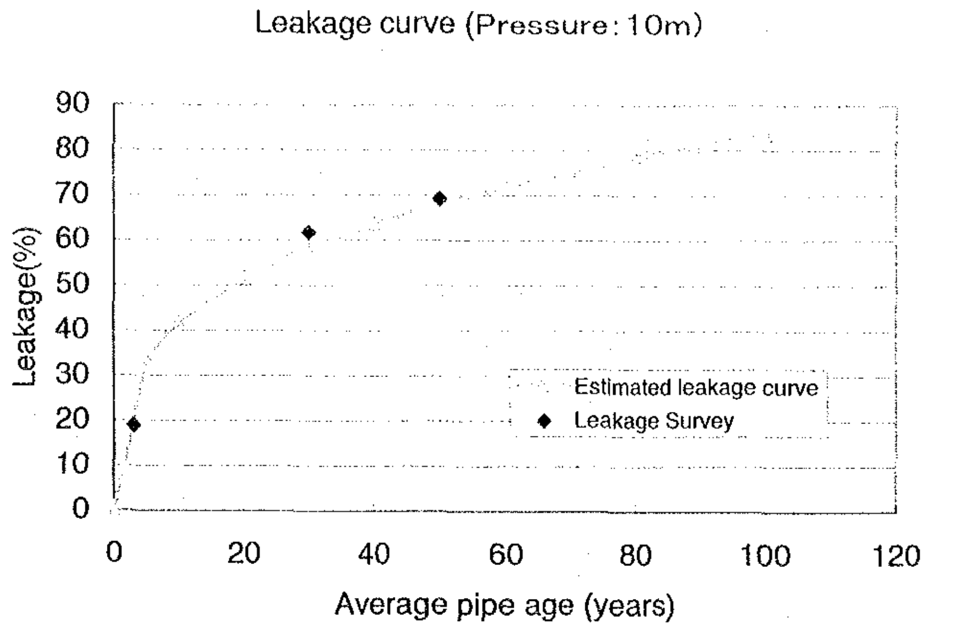
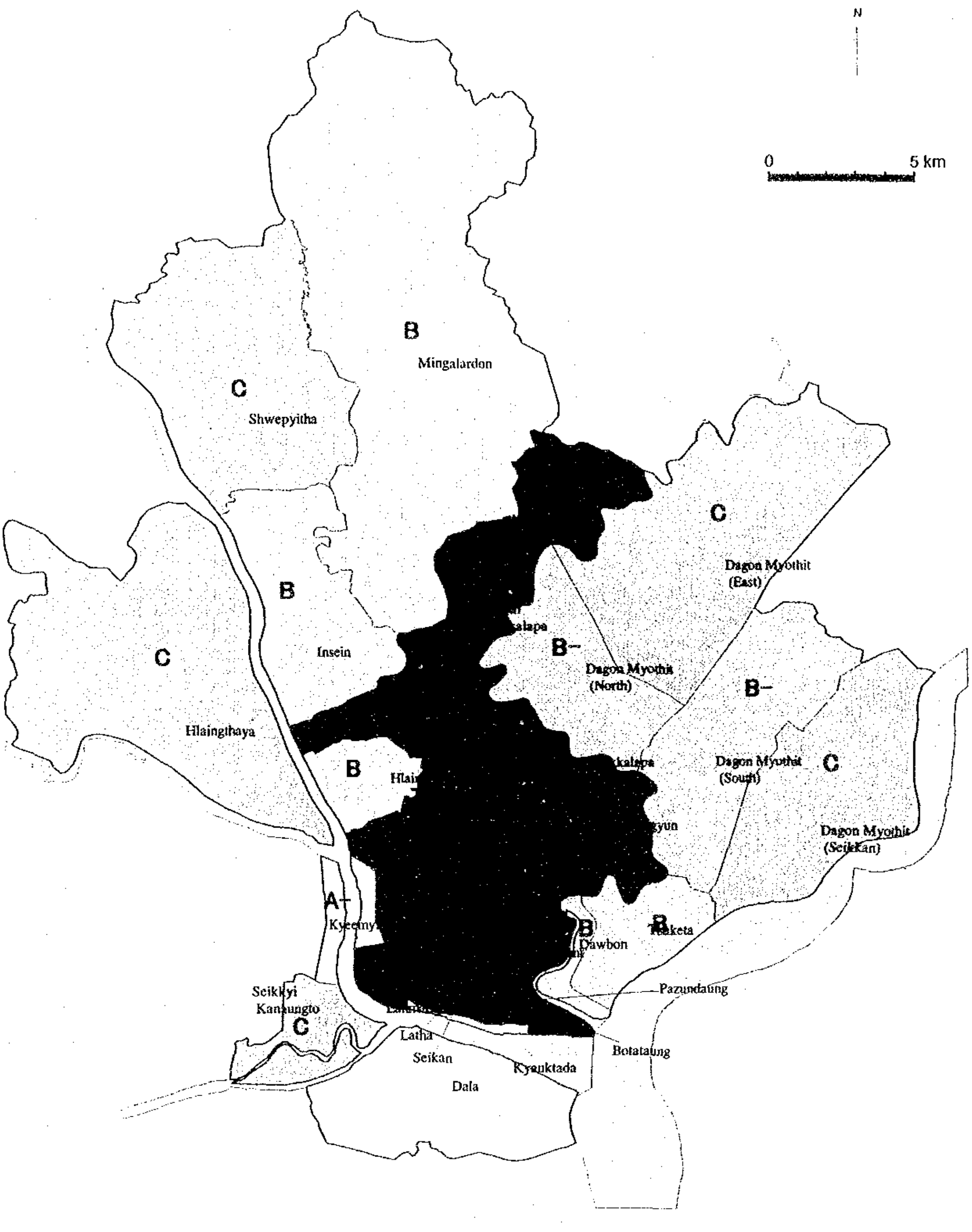


Figure 4.7 Estimated Leakage Curve

From the pipeline investigation, we knew the weighted average age of pipe is 50 years (see figure 3.31). If we apply 50 years age of pipe to the above curve, it will result in leakage ratio of about 65%. However this 65 % is under the 10 m pressure. We also know that the average current pressure for YCDC network is less than 10 m. Since there is no monitoring system for pressure, the average pressure is just a guess work. However based on the field pressure measurements, experiences obtained during this study as well as our own engineering judgments, we conclude 50% of the current leakage ratio is reasonable for planning purposes. In near future, YCDC have to establish a monitoring system in order to determine the accurate leakage ratio.

4.5.3 Township Demand Allocation at the Target Year

In the previous section, the total demand is calculated as 1,912,700 m3/day (420 MGD) with 70 % of service ratio. In order to decide the each township service ratio, we together with YCDC have determined the high priority townships and categorized them as A, A-, B, B-, C and D (see Figure 4.8). At the target year, the townships ranked as "A" are known to have a service ratio of 100 %. The service ratio for other ranked groups is calculated so as to arrive at an overall service ratio of 70 %. Also, we know the forecasted population for each township, which would allow us to estimate demand by township. Figure 4.8 shows categorized township and Table 4.20 shows the demand for each township. Figure 4.9 shows the demand for townships at 2020.



THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR

FIG 4.8

Township Priority

Table 4.20 Demand by Each Township at 2020

No	Township	2020										
					Domestic		Department	Commercial & Industry			Total	Total
		Population (persons)	Service Ratio (%)	Served Pop (persons)	percapita (lpcd)	Total (m^3/day)	Total (m^3/day)	Demand (m^3/day)	Industrial Zone (m^3/day)	Total (m^3/day)	Average Demand (m^3/day)	Maximum Demand (m^3/day)
1	Ahlone	56,916	100%	56,916	200	11,383	797	1,935		1,935	18,820	22,584
2	Bahan	108,789	100%	108,789	200	21,758	1,978	3,699		3,699	36,580	43,896
3	Botataung	63,930	100%	63,930	200	12,786	2,101	2,174		2,174	22,748	27,298
4	Dagon	46,009	100%	46,009	200	9,202	9,983	1,564		1,564	27,665	33,198
5	Dagon Myothit (East)	132,879	33%	44,400	200	8,880	622	1,510	1455	2,965	16,623	19,947
6	Dagon Myothit (North)	244,785	43%	106,271	200	21,254	1,488	3,613		3,613	35,140	42,168
7	Dagon Myothit (Seikkan)	44,010	33%	14,705	200	2,941	206	500	2631	3,131	8,371	10,045
8	Dagon Myothit (South)	337,994	43%	146,736	200	29,347	2,054	4,989	40245	45,234	102,180	122,616
9	Dala	128,712	48%	61,782	200	12,356	865	2,101		2,101	20,429	24,515
10	Dawbon	153,169	56%	85,775	200	17,155	1,201	2,916		2,916	28,363	34,035
11	Hlaing	214,780	56%	120,277	200	24,055	1,684	4,089		4,089	39,771	47,725
12	Hlaingthaya	479,566	33%	160,242	200	32,048	2,243	5,448	20890	26,338	80,839	97,006
13	Insein	383,042	56%	214,503	200	42,901	3,326	7,293	3807	11,100	76,436	91,723
14	Kamaryut	103,206	100%	103,206	200	20,641	1,445	3,509		3,509	34,127	40,952
15	Kyauktada	46,405	100%	46,405	200	9,281	912	1,578		1,578	15,695	18,834
16	Kyeemyindaing	118,075	90%	106,267	200	21,253	1,488	3,613		3,613	35,139	42,166
17	Lanmadaw	42,742	100%	42,742	200	8,548	598	1,453		1,453	14,132	16,958
18	Latha	35,021	100%	35,021	200	7,004	743	1,191		1,191	11,917	14,301
19	Mayangone	292,237	100%	292,237	200	58,447	9,581	9,936		9,936	103,952	124,742
20	Migalardon	327,572	56%	183,440	200	36,688	23,919	6,237	199	6,436	89,391	107,269
21	Mingalartaungnyunt	128,399	100%	128,399	200	25,680	1,798	4,366		4,366	42,459	50,950
22	North Okkalapa	500,395	100%	500,398	200	100,082	7,004	17,013	9249	26,262	177,797	213,357
23	Pabedan	49,969	100%	49,969	200	9,994	700	1,699		1,699	16,524	19,829
24	Pazundaung	43,703	100%	43,703	200	8,741	612	1,486		1,486	14,452	17,342
25	Sanchaung	94,895	100%	94,895	200	18,979	1,329	3,226		3,226	31,379	37,654
26	Seikkan (port)	1,452	28%	407	200	81	6	14		14	135	162
27	Seikgyikhanaungto	47,907	33%	16,008	200	3,202	224	544		544	5,293	6,352
28	Shwepyitha	415,011	33%	138,671	200	27,734	1,941	4,715	7056	11,771	55,261	66,314
29	South Okkalapa	316,213	100%	316,213	200	63,243	4,427	10,751		10,751	104,561	125,474
30	Tamwe	156,906	100%	156,906	200	31,381	2,688	5,335		5,335	52,539	63,046
31	Thaketa	495,984	56%	277,751	200	55,550	4,256	9,444		9,444	92,333	110,800
32	Thingahgyun	387,442	100%	387,442	200	77,488	5,424	13,173		13,173	128,113	153,736
33	Yankin	160,885	100%	160,885	200	32,177	3,437	5,470		5,470	54,779	65,734
	total	6,159,000	70%	4,311,300	200	862,260	101,080	146,584	85532	232,116	1,593,941	1,912,730

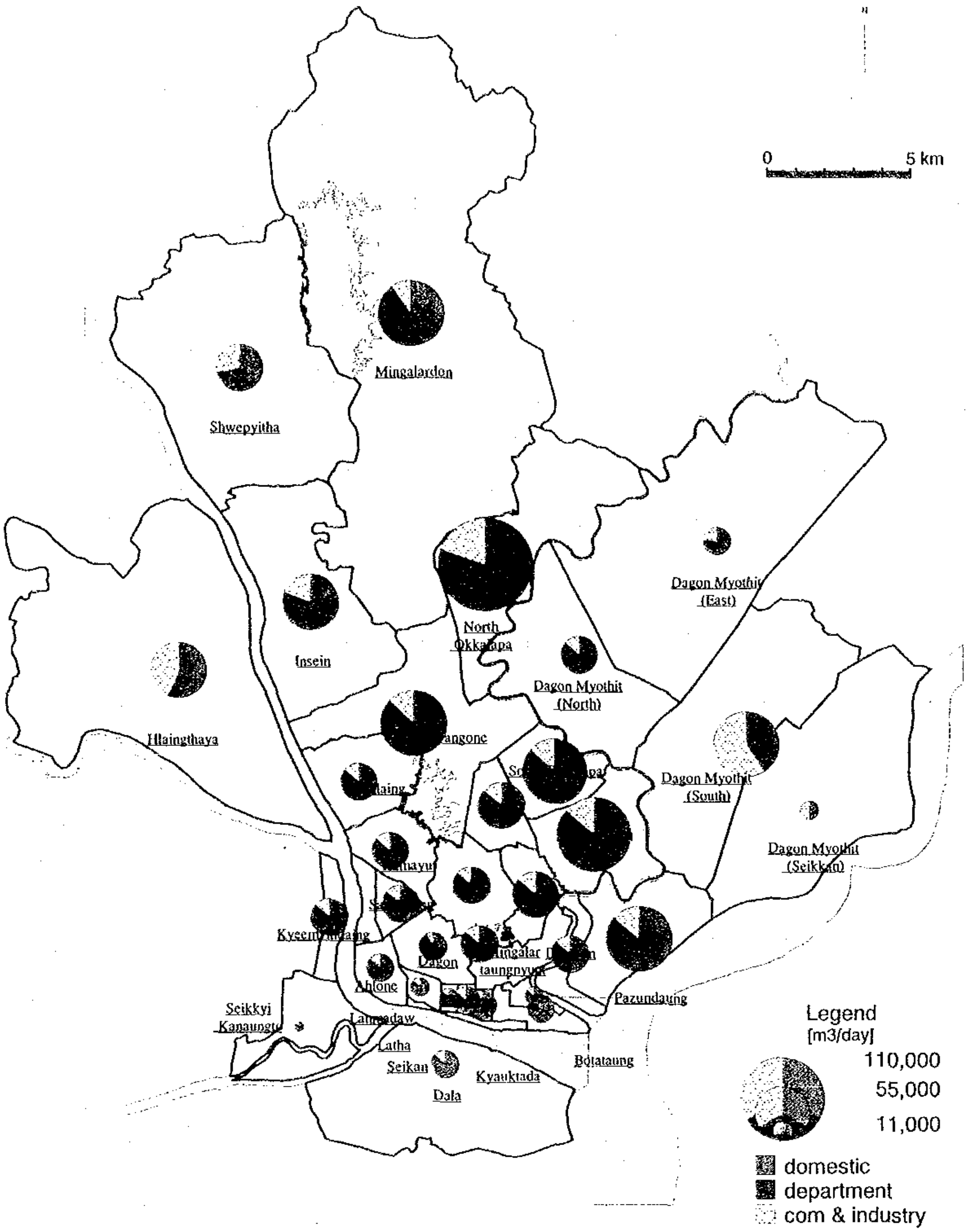


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FIG 4.9

Township Demand at 2020

4.6 CURRENT WATER SOURCES

The existing water sources come from both surface water and groundwater produce 439,440 m^3/day (96.7 mgd) as of 2000.

Surface water (Reservoirs)	: 395,550 m^3/day (87.0 mgd)
Groundwater	: 43,890 m^3/day (9.7 mgd)
Total	: 439,440 m^3/day (96.7 mgd)

This actual production rate is only 71 % of the estimated demand in 2000 (615,134 m^3/day). The current situation is characterized by a severe lack of water and the need for urgent water supply increase to cater for the demand. To meet the demand of 2020 (target year), an additional water supply of 1,473,300 m^3/day (322 mgd) is required. By all standards, this is going to be very large project. Obviously, water source development (increase of water supply) is urgent project.

4.6.1 Surface Water

A total amount of 395,550 m^3/day (87.0 mgd) of surface (reservoir) water is developed from three reservoirs as follows ,

(1) Gyobyu Reservoir

Gyobyu has dependable yield of 93,300 m^3/day (20.5 mgd) and was completed in 1940. It is located at about 64km (40 miles) north of Yangon. Water is carried through 1,400 mm diameter steel pipe to Yegu pumping station by gravity. When the level in the reservoir falls closer to the treatment plant or when the flow is not adequate to meet the demand, 3 low lift pumps are available for raising the amount of flow.

(2) Phugyi Reservoir

Phugyi Reservoir was completed in 1992 and has a dependable yield of 245,700 m^3/day (54mgd) of water, however current production rate is 227,250 m^3/day (50 mgd). Water is transmitted from Phugyi by pumping through a 1,500 mm dia presented concrete pipeline to Hlawga Reservoir.

(3) Hlawga Reservoir

Hlawga Reservoir is situated at about 27 km (17 miles) north of Yangon. It has a dependable yield of 75,000 m^3/day (16.5 mgd) and was completed in 1906. The water from Hlawga is pumped through a 1,050 mm dia cast iron pipeline to Yegu, when it is pumped to the city's distribution system.

4.6.2 Groundwater Production

Groundwater extraction facilities in the City are divided into two categories namely YCDC tube wells and None YCDC dug/tube wells. Groundwater production managed by YCDC was roughly estimated as the annual extraction amount in the year of 2000 using database obtained from YCDC. Annual production of groundwater was estimated in accordance with parameters of system, service level and township. Table 4.21 shows annual production amounts in years of 1998, 1999 and 2000.

Table 4.21 Annual Production Of YCDC Tube Wells

System/Service		Township	Well No.	1998	1999	2000
SW Fed System Combined with GW	Majority of L-III including L-II	Ahlone	10			
		Botataung	2			
		Dagon	7			
		Insein	1			
		Kamayut	2			
		Kyauktada	4			
		Kyeemyindaing	12			
		Lanmadaw	6	12.22	13.23	12.07
		Latha	4			
		North Okkalapa	6			
		Pabedan	3			
		Sanchaung	16			
		South Okkalapa	6			
		Thaketa	17			
		Thingangyun	8			
		Sub-total	**104**	**12.22**	**13.23**	**12.07**
GW Fed Systems or Facilities (independent from SW Fed System)	Majority of L-III including L-II	Dala	3	0.00	0.00	0.74
		Insein	1	0.04	0.04	0.04
			2	0.08	0.08	0.08
		Kamayut	7	0.29	0.31	0.30
			1	Records are not available at present.		
			1	0.12	0.11	0.10
			1	0.16	0.18	0.15
			2	Records are not available at present.		
			3	Records are not available at present.		
			2	Records are not available at present.		
		Mingalartaungnyunt	1	0.12	0.12	0.12
		South Okkalapa	1	0.03	0.03	0.03
		Thingangyun	2	0.03	0.06	0.08
			2	0.12	0.12	0.12
			1	0.04	0.04	0.04
			1	0.02	0.01	0.01
		Sub-total	**31**	**1.05**	**1.10**	**1.81**
	L-II	Dagon	4	0.60	0.60	0.60
		Seikan Port	1	0.50	0.50	0.50
		Sub-total	**5**	**1.09**	**1.09**	**1.10**
	L-I	Dagon Myothit South	32	0.35	0.34	0.34
		Dawbon	7	0.17	0.17	0.17
		Hlaingthaya	7	0.08	0.08	0.08
		North Okkalapa	18	0.34	0.33	0.33
		Shwepyitha	8	0.09	0.09	0.09
		Thingangyun	2	0.02	0.02	0.02
		Sub-total	**74**	**1.06**	**1.04**	**1.04**
	Hydrant	Botataung	1	0.00	0.00	0.00
		Mingalartaungnyunt	1	0.00	0.00	0.00
		Sanchaung	1	0.00	0.00	0.00
		Sub-total	**3**	**0.00**	**0.00**	**0.00**
City Total			**217**	**15.42**	**16.47**	**16.02**

Note: Identifications = System/Service, Township, Well No.; Annual Production Amount (MCM/Y) = 1998, 1999, 2000.

Source; YCDC Township Offices, as of July 2001

4.7 WATER SOURCE POTENTIAL

4.7.1 Surface Water

The present surface water sources for supply to the Yangon City are consisted of Gyobyu Reservoir, Phugyi Reservoir and Hlawga Lake Reservoir operated by YCDC, and Ngamoyeik Reservoir constructed by Irrigation Department. Furthermore, there are 8 reservoirs for irrigation purpose, some of which are existing, under construction and stage of planning. All of them are located around the Yangon City , managed by Irrigation Department.

In order to review and estimate the available water source, the water balance study was conducted at 5 reservoirs, namely Gyobyu Reservoir, Phugyi Reservoir, Hlawga Reservoir, Nagamoyeik Reservoir and Lagunbyin Reservoir.

In addition, the other surface water sources which could possibly provide water to the City are Hlaing River and Bago River.

(1) Reservoir Water Balance Study

The water balance study is simulated the available water source for reservoirs on the basis of monthly runoff at each reservoir. Considering the accuracy and availability of observed data, simulation period adapted for the last 6 years (May 1995-Dec. 2000) with 10 years return period, which covers the severe drought year of 1998.

The results of analysis for the water balance study are summarized in Table 4.22. As seen in Table 4.22, available surface water for Yangon City is confirmed that the existing reservoirs could be developed as future water sources from 893,300 m^3/d (196.5 mgd) in Maximum to 868,300 m^3/d (191.0 mdg) in minimum on condition of maintaining the low water level of each reservoir during the drought year.

Table 4.22 Results of Reservoir Water Balance Study

Name of Reservoir	Low Water-Level (ft)	Water Supply m^3/day (mgd)	
Gyobyu	138.0	93,200 (20.5)	118,200 (26.0)
Phugyi	90.0	245,400 (54.0)	-
Hlawga Lake	47.0	75,000 (16.5)	-
Ngamoyeik	81.0	409,100 (90.0)	-
Lagunbyin	46.0	45,460 (10.0)	-

Based on the results, the following reservoir potential is used for this study.

Gyobyu Reservoir: 118,200 m^3/day (26.0 mgd)
Phugyi Reservoir: 245,400 m^3/day (54.0 mgd)

Hlawga Reservoir: 75,000 m^3/day (16.5 mgd)
Ngamoyeik Reservoir: 409,100 m^3/day (90.0 mgd)
Lagunbyin Reservoir: 45,460 m^3/day (10.0 mgd)

The intake water rights from Lagunbyin reservoir is under negotiation between YCDC and the ministry of irrigation. We recommend to draw 454,600 m^3/day (100 mgd) of water from Nga-myeik reservoir, which is possible and economical, but subject to the approval of water rights. However, in this Master Plan, we do not consider this option.

(2) Surface Water Availability For River Direct Intake

In Hlaing River basin, there is a hydrological station at Khamonseik operated by the Department of Meteorology and Hydrology. Although there are 2 hydrological stations in Bago River basin at Bago and Zaungtu, Bago station has been excluded from one of the key stations because of the influence of tidal level during January to mid-May and mid-October to December. Therefore, there are no observed records during the aforesaid periods of each year at Bago station.

There are 2 reports on river flow measurement records for Hlaing River as follows;

"Feasibility Report on Hlaing River Water Resource for Supply of Water to the City of Rangoon, March 1988), YCDC"

"Hydrometric Survey of Hlaing River for Yangon City Water Supply, June 1992, Department of Meteorology and Hydrology" for "Final Feasibility Study Report on Hliang River Water Supply Project, March 1993"

According to the "1988 Report" flow discharge had been observed to be 105.4 m^3/s (2000 MGD) at Zigon village (before it meets the Bawle River), and 63.2 m^3/s (1200 MGD) at Gwedanshe (after it meets the Bawle River) in February 1988, respectively.

And according to the "1992 Report", the survey team of Department of Meteorology and Hydrology had carried out the hydrometric works of Hlaing River at Gwedanshe and Kyweku sites in April to May, 1992. The results of flow measurements are summarized as follows;

The minimum rate of flow during the low tide period is estimated to be about 7.5 m^3/s on 26th, April. The minimum mean rate of flow during the low tide period is about 63 m^3/s on 27th April.

However, as seen the results of river flow regime (refer to APPENDIX A in Table A.9, Table A.10 and Table A.11), the flow discharge of above study are evaluated to correspond to the high amount of yearly discharge during the dry season. Since the results of above study were included the amount of discharge influenced by tidal level effects, the results of flow measurements are evaluated the excessive amount discharge during the period of low flows.

Based on the results of river flow regime (refer to APPENDIX A in Table A.9), low flow discharges are estimated at the prospective sites as shown in Table 4.23. As seen in Table 4.23, available river flow discharge in design drought year is estimated approximately from 4.3 m^3/s in occurrence of failure of 1 time for 11 years to 11.4 m^3/s in occurrence of failure of 2 times for 11 years at Gwedanshe in Hlaing River. Because its base flow is very poor in Bago River basin, river flow discharge is estimated approximately 1.3 m^3/s in occurrence of failure of 7 times of 14 years at Bago Gauging Station.

Table 4.23 Estimated Low Flow Discharge at the Prospective Sites

River	Site	C.A. (km^2)	Low Discharge (275th daily discharge)			Drought Discharge (355th daily discharge)			Annual Min. Discharge		
			Mean	2/N	1/N	Mean	2/N	1/N	Mean	2/N	1/N
Hlaing	Khamonseik Gauging Stn.	5840	20	11	5	14	8	3	13	8	3
	Kungyangon	7960	27.3	15.0	6.82	19.1	10.9	4.09	17.7	10.9	4.09
	Gwedanshe	8290	28.4	15.6	7.10	19.9	11.4	4.26	18.5	11.4	4.26
	35km Point	8810	30.2	16.6	7.54	21.1	12.1	4.53	19.6	12.1	4.53
	25km Point	8990	30.8	16.9	7.70	21.6	12.3	4.62	20.0	12.3	4.62
Bago	Zaungtu Gauging Stn.	1927	3	0	0	1	0	0	1	0	0
	Bago Gauging Stn.	2580	4.02	-	-	1.34	-	-	1.34	-	-
	35km Point	2970	4.62	-	-	1.54	-	-	1.54	-	-
	30km Point	3220	5.01	-	-	1.67	-	-	1.67	-	-

Note: C.A.: Catchment Area estimated by using map of 1:2,000,000 scale N: No. of Records
1/N: Case of the occurrence of failure of 1 times for 11 years in Hlaing River, and case of the occurrence of failure of 1 times for 14 years in Bago River
2/N: Case of the occurrence of failure of 2 times for 11 years in Hlaing River, and case of the occurrence of failure 2 times for 14 years in Bago River

Considering the above results, the following is concluded,

- It is difficult to intake water from proposed sites at Bago river.
- At Gwedanshe (Hlain river), 11.4 m^3/s (981,500 m^3/day :216 mgd) is considered as intake amount in this Master Plan.
- Two Water Treatment Plants will be planned, one for river water (Hlaing river) and the other is for reservoir water.

4.7.2 Groundwater Development Potential

Presently, there are two types of water supply problems. Firstly as a water quantity, there is a deficit supply compared to the demand resulting in intermittent and low-water-pressure supply conditions. Secondly as a quality, the citizens have compellingly utilized unsafe water sources in right bank of the Hlaing River.

Groundwater potential has two meanings in this study. First one is producible potential from existing tube wells for future allocation and the other is exploitable groundwater for future development.

(1) Producible Groundwater

Presently, one hundred four (104) tube wells are connected to pipe system as shown in Table 4.24. Since water source shortage is occurred, producible groundwater potential from the tube wells was estimated under the available conditions with avoidance of any expedient exorbitantly.

Table 4.24 YCDC Tube Wells in Left Bank of the Hlaing River

System/Facilities	Tube Well			Production	Operation	Township
	Number	S-Pump	Airlift	MCM/Y	Hours/day	Number
Main System	104	83	21	12.07	7.7	15
Level-II/III Systems	33	24	9	2.17	9.9	7
Level-I Facilities	67	4	63	0.96	3.0	5
Total or Average	204	111	93	15.20	6.3	17

Note; Tube wells for hydrant are not included. "S-Pump" means submersible pump. Production amount was recorded in year 2000. Standby tube wells are not included into operation hours. Township numbers are overlapped; total number is not sum up of system wise.

In this regard, present tube wells were allotted to the regular or abandoned in future use. In other wards, tube well without any problems shall be used for water supply system even after water source deficit is solved. Evaluation criteria for that classification are existence of problems in terms of water quality, yielding and well structure. To assume groundwater quality, parameter of electric conductivity (EC) was examined at all tube well sites in September 2001. Out of 104 tube wells belonging to the main system, regular tube wells were totaled at 75. Consequently, 75 tube wells shall be improved, while remaining 29 tube wells shall be used on condition of present.

In the year 2000, average daily pump operation in the main system was estimated at only 7.7hrs with annual total production of 12.07MCM/Y statistically. It means that the duration times of daily high water consumption have restricted to the management of pump operation. Accordingly, longer pump operation makes larger production amount.Daily pump operation time of 16hrs is adaptable condition to fit the YCDC management. Table 4.25 shows comparison between present and after improvement of objective 75 tube wells.

Tube well deterioration shall be considered for future forecasting. In this study, mere 3% of annual reduction was assumed for available productive amount. At the year 2020, 54% of present production was assumed as hypothetical well potential on a single well base, because the YCDC has no experience of actual tube well re-development for recovery of tube well performance.

Table 4.25 Comparison of Tube Well Producible Amount

Items	Present		After Improvement		Remarks
	Regular	Abandoned	Regular	Abandoned	
Tube Well	75	29	75	29	ditto
(well number)	104		104		
Daily Operation	**7.2**	9.3	**16.0**	9.3	+8.8
(hrs/day)	7.7		14.1		+6.4
Annual Production	**10.25**	1.82	**22.56**	1.82	+12.31
(MCM/Y)	12.07		24.38		

Source; Tube Well Database, as of July 2001

(2) Exploitable Groundwater

Exploitable groundwater potential was presumed with due considerations of practical trials and assumptions. In this study, exploitable groundwater potentials by township wise were aggressively estimated. The exploitable groundwater potential means the sustained yield, groundwater amount of which is possible value of exploitation extending over a long time without any environmental problems influentially. In this regard, development availability can be said equal to the balance of such potential and present extraction.

To estimate the exploitable groundwater potential by Township wise seems to be a complicated demand technically. It is significance to create the supporting information on general trends as the situations of groundwater with showing theoretical process even including dubious assumptions. This groundwater study consists of three steps below.

- Step-I: Estimation of Groundwater Recharge
- Step-II: Assumption of Sustained Yield
- Step-III: Evaluation of Development Potential

<Estimation of Groundwater Recharge>

Groundwater recharge was estimated as the sum up of: 1) meteorological recharge, 2) artificial recharge and 3) groundwater balance of inflow from and outflow to.

1) Meteorological Recharge

By definition, groundwater recharge is the inflow flux to a groundwater basin. There are two basic methods to estimate groundwater recharge, one of which is to use a water balance approach and the other one is to use the estimation based on empirical methods. The water balance approach is generally used as in the following equation.

$$P = Et + Sr + Gr + Sm$$

Where: **P**; Precipitation
Et; Evapotranspiration (= Evaporation + Transpiration)
Sr; Surface Run-off
Gr; Groundwater Recharge
Sm; Soil Moisture (ignore)

The values of monthly precipitation, evapotranspiration and surface run-off were estimated by ground surface categories. Following Table 4.26 shows summarized share rates of rainfall/meteorological cycle by the categories of ground surface type.

Table 4.26 Share Rates Of Meteorological Cycle

Meteorological Items	Ground Surface Land Use				
	Forest	Farm	Built-up	Paddy	Swamp
Evapotranspiration	36.4%	32.4%	29.4%	26.3%	24.3%
Surface Run-off	38.2%	47.3%	56.5%	66.3%	75.7%
Recharge	25.4%	20.3%	14.1%	7.4%	0.0%

Note: Monthly estimation details are referred to Appendix-B.

Using annual precipitation, an annual total amount of the meteorological recharge in the city, at 11.9% of precipitation as the city total, was totaled at 201.82 MCM/Y.

2) Artificial Recharge

Artificial recharge factors are composed of irrigated water in paddy fields and leakage water from water supply pipeline systems owned by the YCDC and the None YCDC. Artificial recharge amount in the city was estimated at 71.13 MCM/Y with procedures below.

Recharge amount of irrigation water for paddy land was assumed by planting duration, specified period and planting rate. Additional recharge was estimated from dry season only with assumed planting rate. Recharge amount from irrigation water was estimates at 9.21 MCM/Y in the city.

Pipeline leakage was estimated at first, then permeation rate of leakage water was assumed by pipeline situation. Leakage rate against water supply amounts were assumed based on the study results of intake measurement. Total amount of leakage in the city was estimated at 206.40MCM/Y. Depending on the leakage levels, recharge conditions are quite variable. Most water is recharged in case of small leakage, while most water is run-off adversely in other case. Recharge amount from leakage water was estimated at 61.92 MCM/Y in the city.

3) Groundwater Balance

Using expected hydrogeological boundary, directions and proportions of groundwater inflow from and outflow to other Townships in the central city area (between Ngamoeyeik Creek and Hlaing River) were assumed based on supposing that groundwater cycle is balanced annually. According to this groundwater balancing condition, the annual recharge value corresponding to proportion estimated in upstream Townships is supposed to the inflow value for the downstream Townships.

As a matter of course, when groundwater has been exploited in the upstream area, new proportion of balancing flow will be bone instead of previous proportion. The groundwater inflow value in 16 Townships was estimated at 80.92 MCM/Y. However, this amount is just like a value of internal lending and borrowing in the same wallet. Townships, extensive delta plain is located at the back of which, may have much larger amount of groundwater inflow.

<Assumption of Sustained Yield>
Generally, permissive limitation of water level lowering is set up at first in terms of environmental problems and human benefits. There is no observation well that is for examination of groundwater quality and/or is for sounding of groundwater levels. Therefore, setting up of mere proportion methodology to estimate the sustained yield was adopted. Permissive rates of proportional recharge were due consideration of topographical and geological conditions.

Recharge water has been used for the system-action of present hydraulic cycle. On the other hand, groundwater balancing is easily re-formed by the variables of recharge and extraction. It is noted that since geological origins and under ground recharge background are different, two rates were set up for recent alluvium at eastern and western. Following Table 4.27 shows assumption values of percentage rates.

Table 4.27 Permissive Rates for Sustained Yield

Geological Age		Rock Unit			Permissive Rate	
System	Series	Lithofaces		Formation	West	East
Quaternary	Holocene	Q_H	Alluvium	Quaternary Deposits	75%	35%
	Pleistocene	Q_P	Delta		60%	
Tertiary	Pliocene	T_{Pc}	Clay	Ayeyawaddy Series	5%	
		T_{Psa}	Sandstone		30%	
	Miocene	T_{Ma}	Alternation	Pegu Group	15%	
	Oligocene	T_{Osa}	Sandstone		25%	
		T_{Osh}	Shale		5%	

Note; Permissive rates were assumed by this study.

In the study results of sustained yield, highest percentage of 75% falls on Townships of Dala, Hlaingthaya and Seikkyi Kanaungto and lowest one falls on Yankin Township. At the city level, 39% of recharge value was evaluated as sustained yield. The sustained yield was estimated at Township level, the city total of which was totaled at 137.90 MCM/Y. Townships falling on small sustained yield are Dawbon, Pazundaung and Yankin.

<Evaluation of Development Potential>
Since present amount of groundwater extraction was totaled with "the YCDC" and "the None YCDC" wells, development availability was estimated as a remaining. Major indexes are groundwater recharge, development potential, present extraction and development availability. The indexes and the unit indexes were simply compared, which is shown in Table 4.28 by urban (18 Townships) and rural (15 Townships) grouping.

Table 4.28 Comparison of Indexes by Urban & Rural

Category		Area	Recharge	Potential	Extraction	Availability
Township	Unit	km^2	MCM/Y	MCM/Y	MCM/Y	MCM/Y
	Urban	65.11	106.09	44.01	13.06	30.95
	Rural	543.97	247.78	93.89	22.89	71.00
Unit Area	Unit	-	MCM/Y km^2	MCM/Y km^2	MCM/Y km^2	MCM/Y km^2
	Urban	-	1.63	0.68	0.20	0.48
	Rural	-	0.46	0.17	0.04	0.13

Note; Rural Townships were Dagon Myothit East, Dagon Myothit North, Dagon Myothit Seikkan, Dagon Myothit South, Dala, Hlaing, Hlaingthaya, Insein, Mayangone, Mingalardon, North Okkalapa, Seikkyi Kanaungto, Shwepyitha, Thaketa and Thingangyun.

In Table 4.28, it can be seen that there is large difference between the indexes of water cycle. The gap of availability is originated from the recharge values. Significant recharge values of leakage and inflow make such gap. This situation means that water level shall be observed carefully in urban area until when the leakage reduction program is promoted and completed by the YCDC.

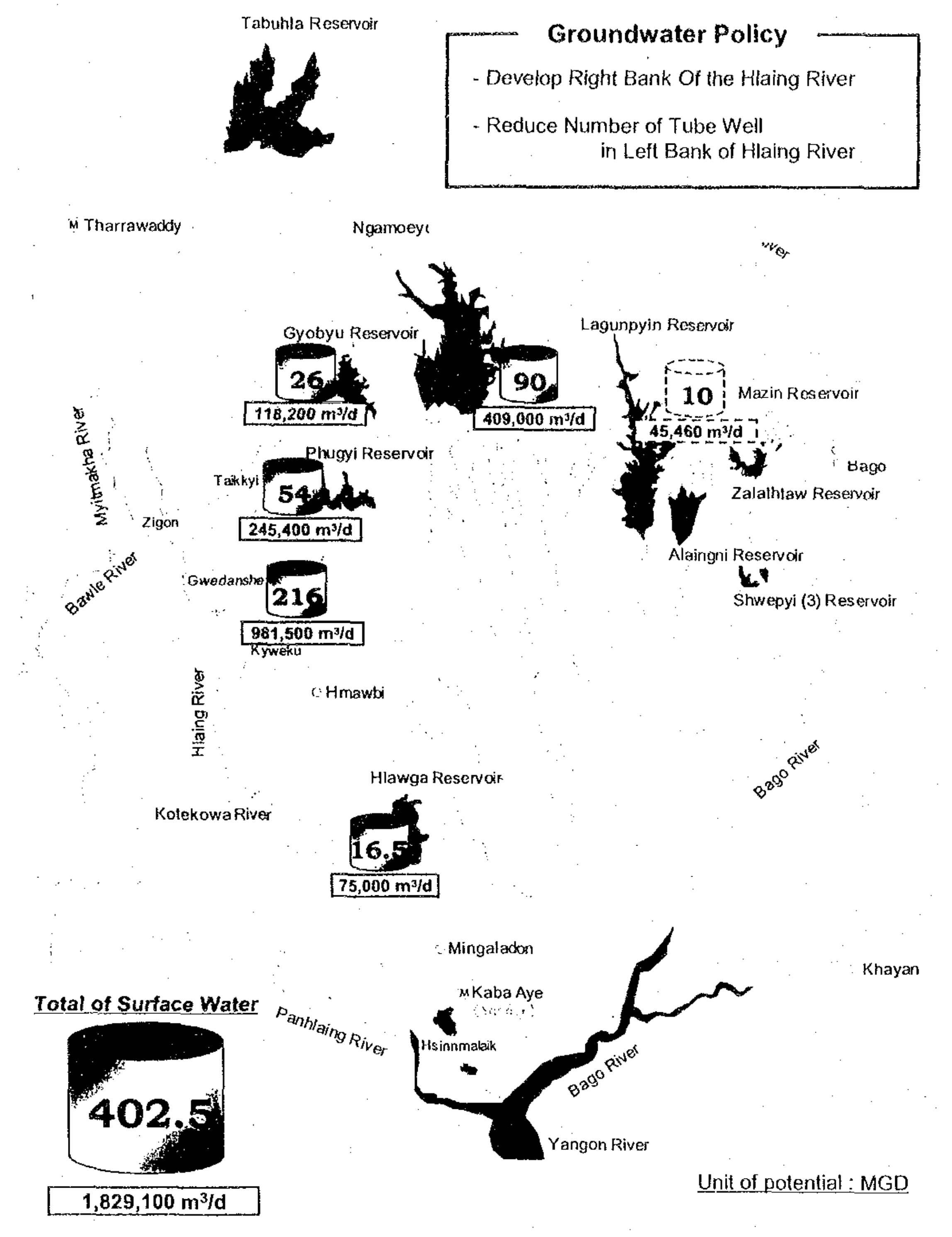
Additionally, water level lowering might be observed in some Townships even now. It is remarkably notified as a kind of worst that the negative groundwater availability in the Townships of Ahlone, Dagon Myothit South and Lanmadaw were estimated because of probable over exploitation.

Consequently, groundwater development in urban/central Townships for the main water supply system is not recommendable plan. New surface water source is rather developed than groundwater for city proper/downtown. On the other hand, groundwater development is recommendable for construction of water supply systems in the right bank of Haling River to improve their sanitary environment.

The policy for groundwater development is summarized below,

- Groundwater development will be planned in the right bank of Hlaing River, namely, Dala, part of Kyeemyinndaing, Seikkyi Kanaungto, and Hlaingthaya townships, on the other hands, existing tube well number is planned to be decreased.
- At the target year, about 157,800 m3/day of water have to be supplied by Tube wells, which is about 8 % of total demand (1,912,729 m3/day).

Figure 4.10 shows surface water potential.



THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR

Surface Water Potential

FIG 4.10

4.8 ZONING SYSTEM

In an attempt to improve water supply system in terms of providing adequate pressure and quantity, it is necessary to create the zoning system. This section describes the concept and the methodology for zoning system beginning from definition of terms.

4.8.1 Terminology

The followings are the definition of terminology of transmission and distribution facilities used in this report. Figure 4.11 shows a conceptual layout of a typical water supply system composed of these facilities.

Raw water main (RWM): A main pipe constructed for conveying water from a source of supply to a treatment plant.

Transmission main (TM): Transmission mains consist of components that are designed to convey large amounts of water over great distances, typically between major facilities within the system, for example, between a treatment plant and a service reservoir, one service reservoir and another, or a pumping station to a service reservoir. Individual customers are not served from transmission mains.

Service reservoir (SR): Storage the treated water for distribution.

Distribution main (DM): Distribution mains are an intermediate step toward delivering water to the end customers. Distribution mains are smaller in diameter than transmission mains. Frequently, distribution mains are connected to service reservoirs.

Secondary distribution main (SDM): Secondary distribution mains are connected to a distribution main and are smaller in diameter than distribution mains.

Service line (SL): Service lines transmit the water from the distribution mains or secondary mains to the end customers.

Transmission pump (TP): Transmission pumps are used for increasing water pressure within the transmission system.

Distribution pump (DP): Distribution pumps are used for increasing water pressure within the distribution system.

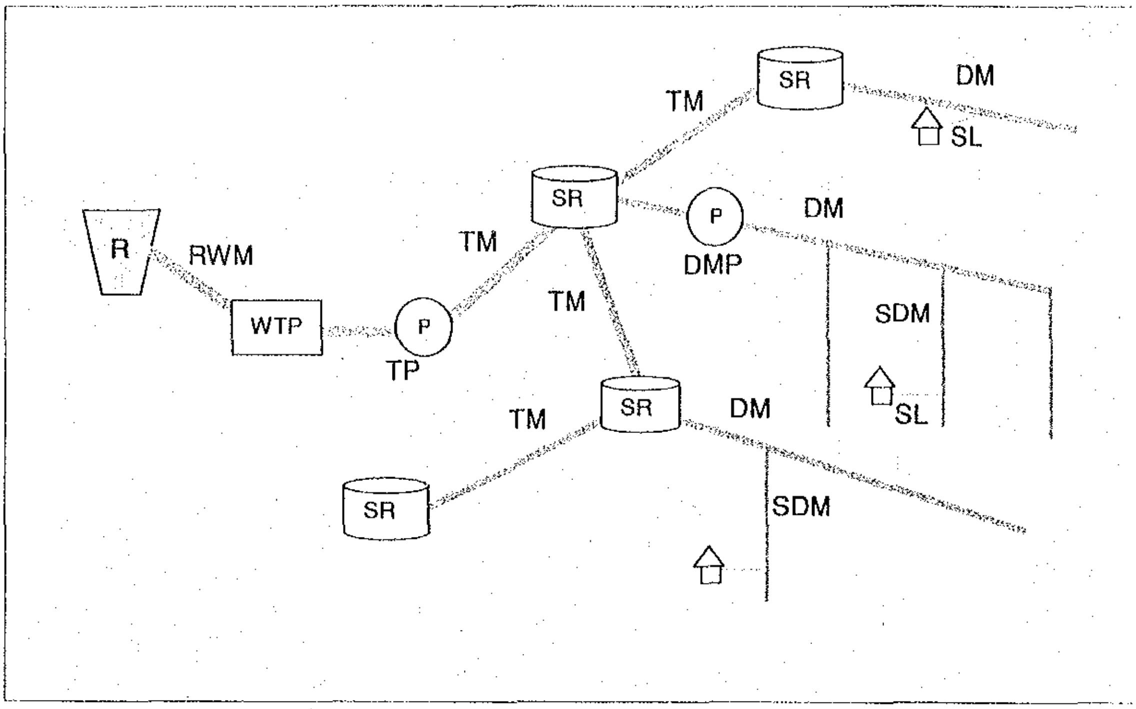


Figure 4.11 Conceptual layout of typical water supply system

4.8.2 Zoning Fundamentals

(1) Separation of distribution system from transmission system

A conceptual layout of the existing network system is shown in Figure 4.12.

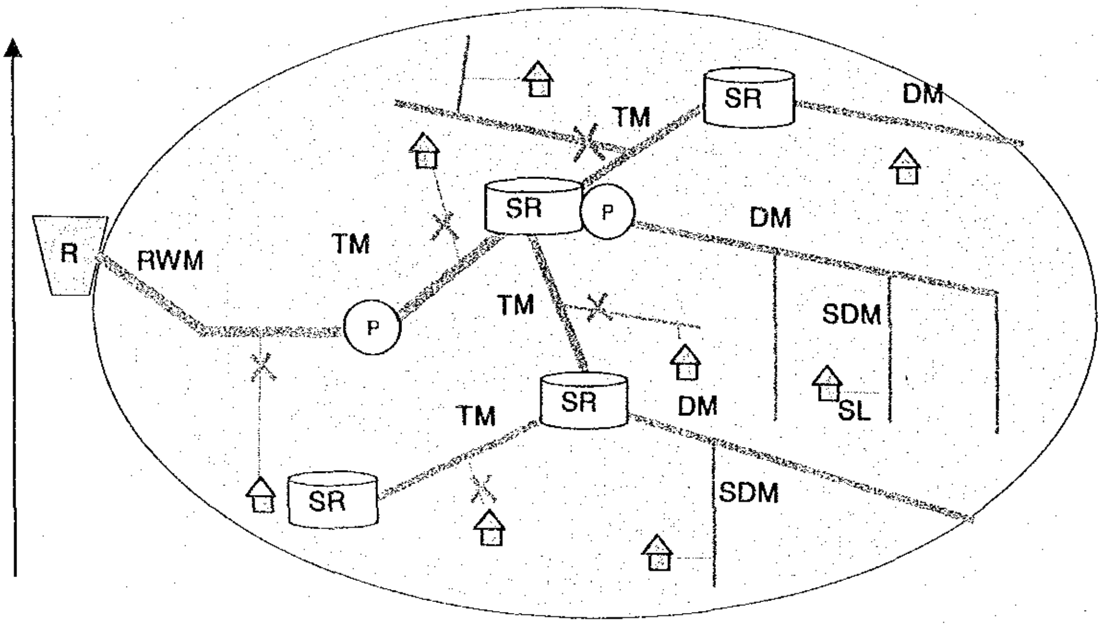


Figure 4.12 Existing Water Supply System (Non-Zoning System: One Distribution System)

In the existing water supply system, many off-takes (shown as x in the figure) from the transmission mains, typically 6" or 8", particularly along the 56" Gyobyu pipeline, are observed. These off-takes make unclear the functions and conditions of the transmission and distribution system as well as the operation and maintenance much be complicated. Moreover, it is very difficult to monitor and control water supply conditions (flow and pressure) in the system.

The followings are advantages of the system where distribution system is separated from transmission system.

- Easy monitoring of flow rate and pressure in the transmission system and the distribution system.
- Easy and fair allocation of water to each water zone.
- Smaller size and costs of the water supply facility.

With the separated system, transmission and distribution systems must be designed with daily maximum and hourly peak water demand, respectively. While without the separated system, all system can be designed with the hourly peak water demand, which results in larger capacity of water supply facilities.

Since these advantages, it is proposed that the distribution system is separated from the transmission system. To achieve the separation, all off-takes should be disconnected from the transmission mains in future.

(2) Advantages of zoning system

There are several advantages of a zoning system listed below,.

- Easy monitoring and control of flow rates and pressure in the zones
- Easy monitoring and control of leakages
- Easy operation and maintenance by zone

Generally, as the water supply area is larger, the operation and maintenance of the system is become more complicated. But even in the large water supply system, introduction of a zoning system makes the operation and maintenance efficient and less complicated. In a large water supply system like Yangon city, a zoning system should be introduced to manage the system efficiently. The conceptual layout of separation of distribution from transmission system and zoning system is shown in Figure 4.13.

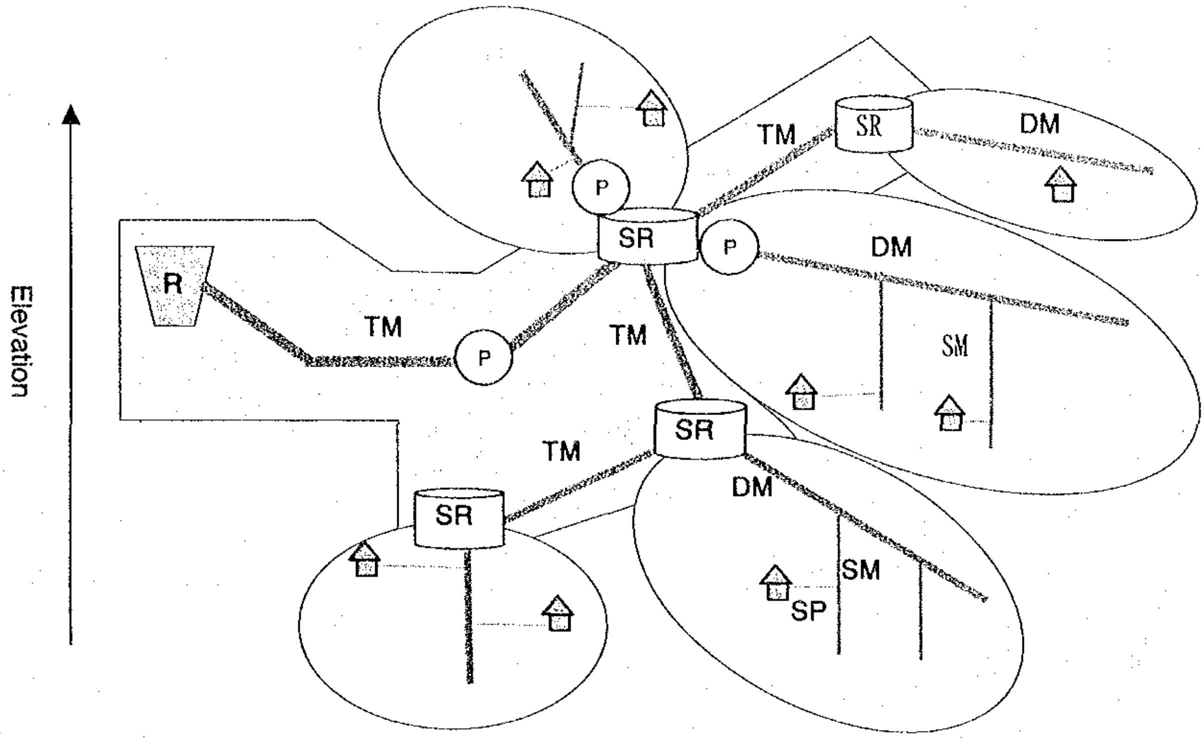


Figure 4.13 Proposed water supply system
(Zoning system: a transmission system and several distribution zones)

4.8.3 Design Criteria

Design flows and formulas and conditions used in planning and designing the transmission and distribution systems are set up as below.

Design Flows and Formulas

(1) Daily average water demand (m^3/day):Qave
Daily average water demand is calculated by dividing annual total water demand by 365 days.
Qave = Annual total water demand / 365 days

(2) Daily maximum water demand (m^3/day): Qmax
This demand generally occurs during the hot season, when people consume maximum amount of water.

= Design capacity for water sources, intake, raw water main, treatment plant, transmission system (mains and pumps)

For Yangon City
>> Peak factor = 1.2 of the daily average water demand (Qmax = 1.2 x Qave)
Remarks: For the design capacity of water sources, intakes or raw water mains, water loss in the

water treatment plans shall be added to the daily maximum water demand.

(3) Hourly maximum water demand (m^3/day): Qhr
= Design capacity for distribution system (mains and pumps)
For Yangon City
>> Hourly Factor = 1.4 of the average hourly demand in the daily maximum water demand (Qhr = 1.4 x Qmax)

(4) Daily demand profile
= Design capacity for service reservoirs
For Yangon City
>> Storage volume = 8-hours demand of hourly average of the daily maximum demand

(5) Pressure requirement
A minimum distribution pressure in the mains is 15 m head (1.5 kg/cm^2), which ensures that water is supplied to the second or third floor.

(6) Pipe friction formula
Hazen-Williams formula is used to analyze the existing water supply system and to design the proposed new pipelines.

$$H = 10.666\, C^{-1.85} D^{-4.87} Q^{1.85} \cdot L$$

Where: H = head loss due to friction (m)
Q = pipeline flow rate (m^3/sec)
D = diameter (m)
L = distance between section 1 and 2 (m)
C = Hazen-Williams C-factor
Existing pipes: the values estimated from pipe conditions
New pipes: 120 (considering local losses and friction increase with age by 2020)

(7) Network analysis software
Following software is used to analyze the present network system and to design future network systems.

- Info Works WS Ver.3.5, Water Research Center

4.8.4 Planning Conditions

(1) Water Demand

Table 4.29 shows summary of planned yearly water demand from 2000 to the target year of 2020. The details for water demand estimation are explained in section 4.5.2.

Table 4.29 Summary of Water Demand

	2000	2005	2010	2015	2020
Population	3,887,000	4,403,000	4,955,000	5,541,000	6,159,000
Service Population	1,443,441	2,201,500	2,973,000	3,601,650	4,311,300
Service ratio (%)	37	50	60	65	70
Net consumption (m^3/day)	256,306	495,131	733,012	970,730	1,195,456
Leakage ratio (%)	50	45	40	35	25
Average water demand (m^3/day)	512,612	900,238	1,221,687	1,493,443	1,593,941
Maximum water demand (m^3/day)	615,134	1,080,286	1,466,024	1,792,131	1,912,729

For network analysis of the year 2000 and 2020, water demands by wards are prepared. For small wards, the water demands by ward are adopted but for large wards, the ward is divided equally into 2 to 6 sections according to the largeness of the ward and water demand of the ward is distributed equally into these sections.

(2) Water Source

The existing and proposed water sources for YCDC water supply system are summarized in Table 4.30.

Table 4.30 Water Sources Summary

Name of source	Existing or new	Source amount (m^3/day)
A. Reservoir		
a) Hlawga reservoir	Existing source	75,000
b) Gyobyu reservoir	Existing source	118,200
c) Pyujyi reservoir	Existing source	245,400
d) Ngamoiyeik reservoir	New source	409,000
Sub-total		847,600
B. Groundwater	Existing and new	158,500
C. Hlaing river	New source	981,500
Total		1,987,600

The water sources are categorized into three source systems: reservoir system, Hlaing river system and groundwater system.

(3) Water Treatment Plant

All the water of the reservoir system are conveyed from the source to the Hlawga reservoir area and treated in bulk with direct filtration process (Hlawga WTP). On the other hand, Hlaing river water is drawn at Gwandansha and treated with coagulation and filtration process at the site (Hlaing WTP). Then the treated water is conveyed to the city area for distribution. Groundwater, especially right bank of Hlaing river, is withdrawn and treated with disinfection and injected into distribution system. However, groundwater in Hlaingthaya township is high concentration of manganese and iron, which will be treated with appropriate treatment process and injected into distribution system.

4.8.5 Proposed Transmission ad Distribution System

Three sources, reservoir, river and groundwater, are planned for the future city water supply. Groundwater is small potion of total amount of the source and will be injected on the site where the water is withdrawn. On the other hand, reservoir and river sources are located in remote area of the city and need to convey to the city area for distribution. Therefore reservoir and river sources are mainly considered when transmission and distribution system is planned.

(1) Transmission System Alternative

1) Alternatives

As stated in the planning conditions, reservoir and river water is separately treated in bulk. These two source systems are called reservoir system and river system respectively. After treatment, both waters should be conveyed to the city area for distribution. Based on the two systems, following two alternatives for the transmission system are cosidered.

Alternative A: Combined System (CS)

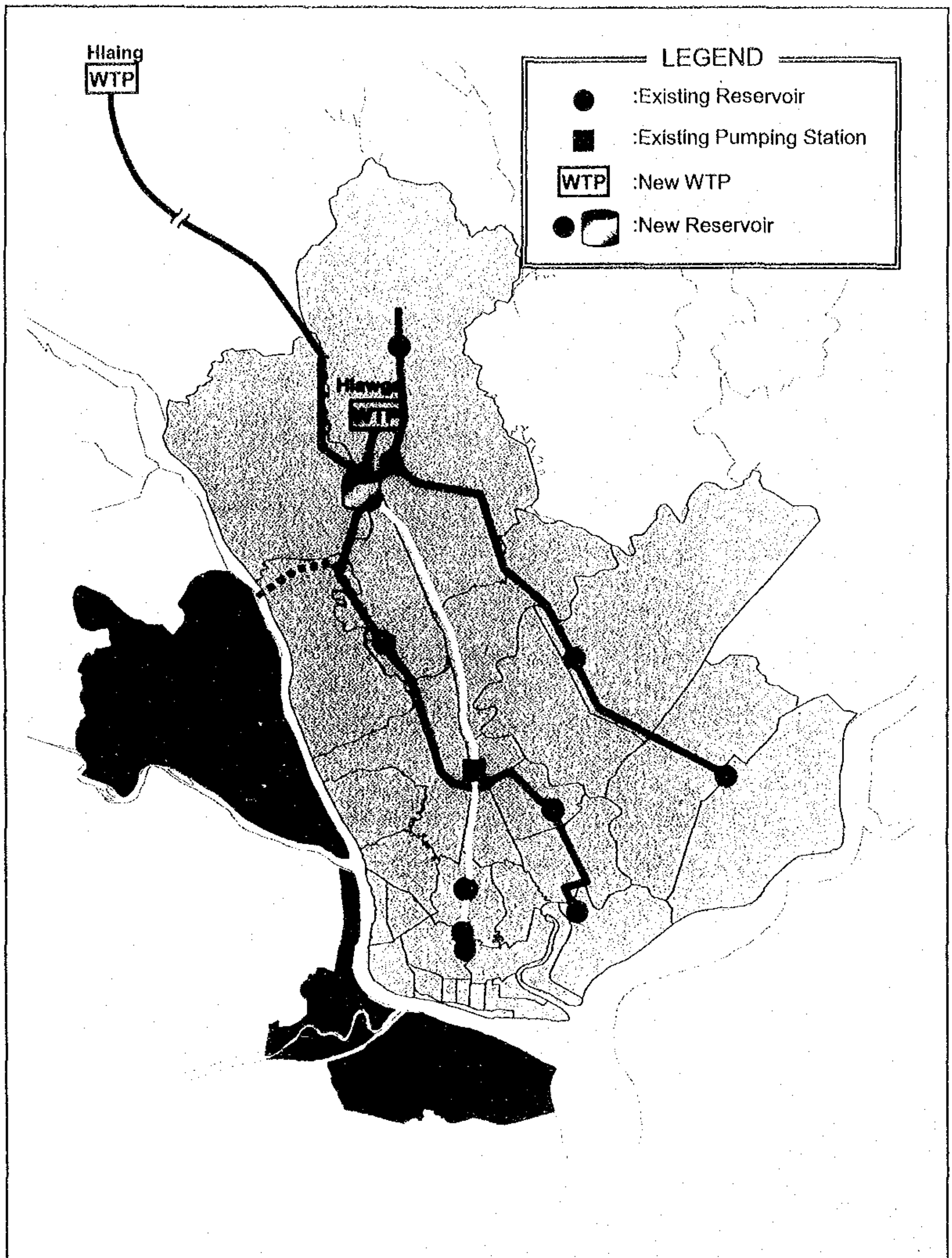
The river system and the reservoir system are combined at the Terminal Reservoir and both source waters are mixed. Then mixed water is transmitted to service reservoirs and distributed at each service reservoir to customers. A conceptual layout of this alternative is shown in figure 4.14. In this transmission system, two major pipelines will be laid along the central ridge of the city and in the eastern city.

Alternative B: Separate System (SS)

The river system and reservoir system are separated and each system's water is separately transmitted to service reservoirs of the zones covered by each system. Then water is distributed from each service reservoir. A conceptual layout of this alternative is shown in figure 4.15. In this transmission system, two major pipelines will be laid in the western low land and in the eastern city. The river system and the reservoir system cover the western city and the eastern city, respectively.

2) *Comparison of Alternatives*

Both alternatives are compared in Table 4.31 and Combined System is proposed for the future water supply system of the Yangon city, because of the advantages in flexible source management, higher reliability, less complicated operation and maintenance, and large water supply areas in the transitional stage to the new system.



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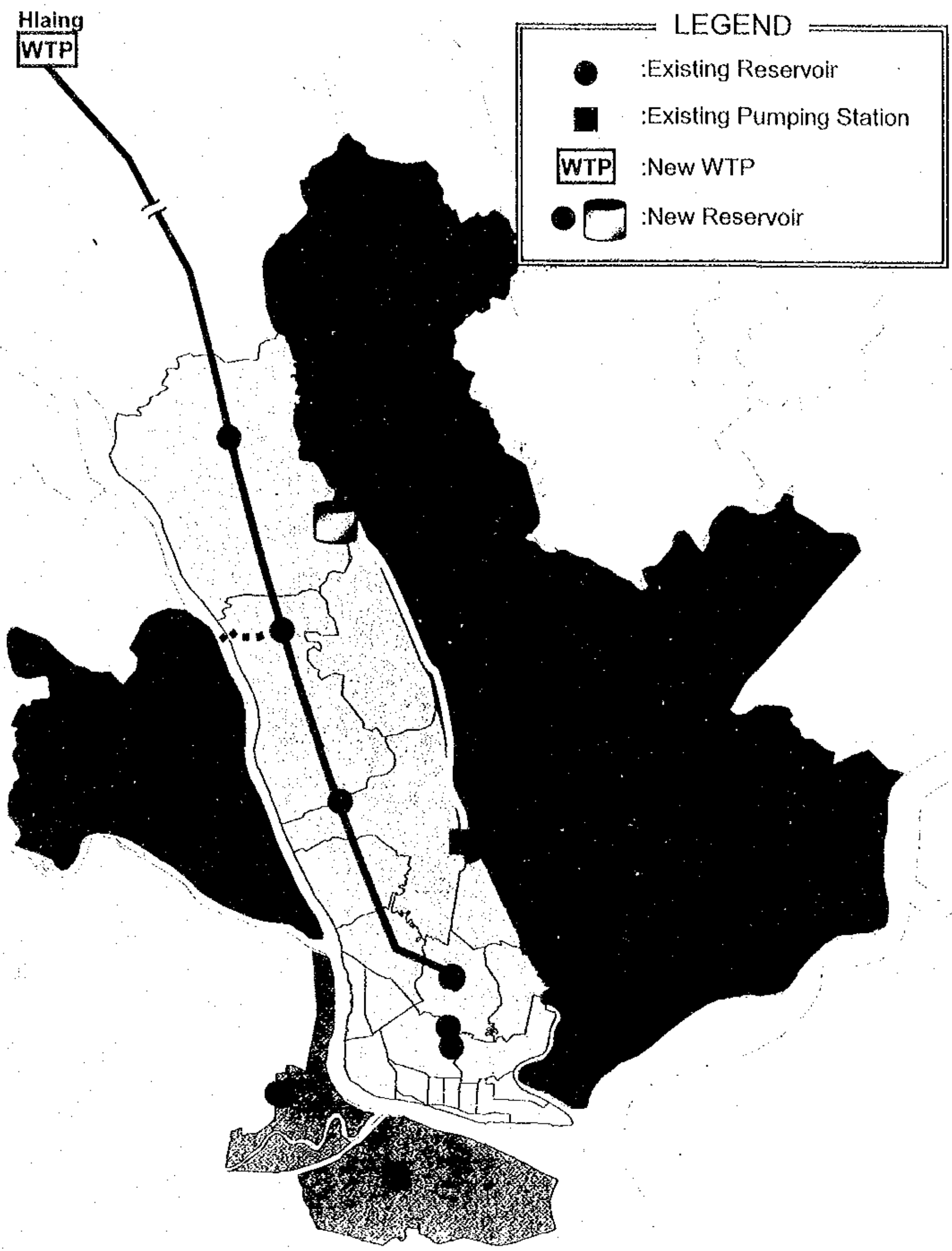
Combined System

FIG 4.14



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Separate System

FIG 4.15

Table 4.31 Comparison of transmission system alternatives

Item	Combined System (CS)	Separate System (SS)
Water source management	Flexible operation of source systems Amount and time of use of water sources can be managed depending on water demand or conditions of water sources. A management plan is necessary.	Rigid operation of source systems Each source system has fixed distribution zones, which makes the operation rigid.
Water supply reliability	If one of the two source systems has an accident, the other source can supply water to all the city area.	If one of the source systems has an accident, water supply will be suspended in the supply area covered by the accident system.
Operation and maintenance	The number of transmission and distribution pumping stations can be decreased. The most of water supply zones are covered by gravity flow distribution from service reservoir. The operation and maintenance can be easy.	Many transmission and distribution pumping stations are required. The most of water supply zones are covered by pumping. The operation and maintenance is complicated.
Operation and maintenance costs	If both source systems are managed properly, treatment and transmission costs can be reduced.	The operation and management costs for separated two systems must cost much.
Construction cost		More transmission lines than the combined system are required, which increases the construction costs.
Transitional stage	Without the river system, the reservoir system can transmit the water to all the service area.	Without the river system, it is difficult to transmit the water to the western parts of the city. So the both systems must be simultaneously constructed to cover all the service areas. A large initial investment is required.

4.8.6 Creation of a Zoning System

(1) Preconditions

A zoning system is introduced to the existing system based on following conditions.

1) *Natural system*

When the zoning system is selected, topography and natural system (river lake, etc) are the most important factor. The city area is divided by major three rivers, Ngamoiyeik Creek, Hlaing River and Yangon River. By dividing these rivers, the city area, or the water supply area, is divided into three major blocks as shown in Figure 4.16. These three blocks are called East, Central and West Blocks, respectively. Other natural systems such as Hlawga reservoir are also considered.

2) Administrative boundaries
Administratively, it is convenient that zoning boundaries should be the same as township boundaries as possible.

3) Artificial structures
Locations and size of roads, streets, railway and vacant lands are considered for the routes of pipelines.

4) Availability of land
Land should be available for proposed water supply facilities.

(2) Distribution zoning concepts
1) Service reservoir
One service reservoir should cover one zone except the area covering existing service reservoirs and the location of service reservoir should be center of the zone as much as possible.

2) Terminal Reservoir
Terminal Reservoir, where the treated water from both the river and reservoir system are mixed, will be located near the Hlawga No.1 Pumping Station. The elevation of the proposed site should be less than 45 feet to draw the Hlawga reservoir water with gravity.

3) East Block
The elevation of this block ranges from about 10 feet (3 m) to 30 feet (9 m). There is no high land where water can be supply with gravity flow. In this block, water must be supplied with pump. Considering township boundaries and the area and extent of the block, it is appropriate that three zones are established. To convey water to each zone from the Terminal Reservoir, a transmission main will be laid along the center of the Block. An analysis is required whether water should be conveyed from this main or Central Block to the most southern area, Thaketa and Dawbon.

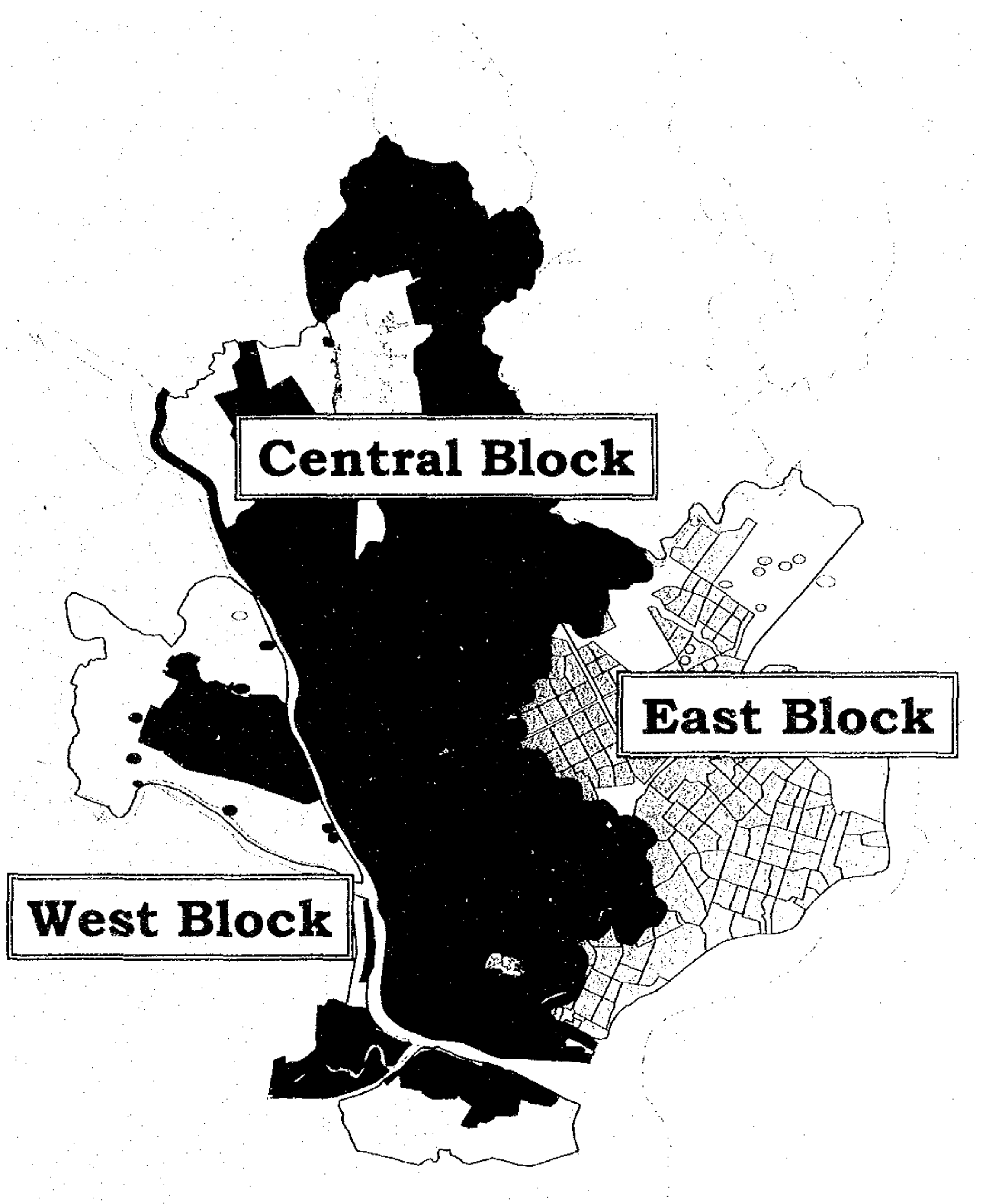
4) Central Block
The elevation of this block ranges from about 10 feet (3 m) to 120 feet (37 m). To supply water with gravity in the most area in this block, service reservoirs should be located in the central ridge of the city and a transmission main also should be located along this ridge. To distribute water to the edge of the each zone, the elevation of service reservoirs should be at least 120 feet (37 m). This high elevation is recognized only two areas in this Block. One is the east of Hlawga reservoir and the other is the north of the airport. These two areas are considered for proposed sites of reservoirs.

When zoning is designed in this block, the existing service reservoirs, Kokine, Central and Shwedagon cover a zone of the downtown area and existing transmission mains are used to fill these reservoirs. The total capacity of these three reservoirs is 31 million gallons (MG) (141,500 m^3). The design capacity of service reservoir is 8 hours of maximum water demand. So about 450,000 m^3 can be supplied from the existing reservoirs. A zone will be made for covering this demand in the downtown area. For the rest of the area, four (4) zones will be appropriate considering the topography and township boundaries.

As stated in planning of the East Block, an analysis is required whether water should be conveyed from Central Block or from East Block.

5) West Block

The elevation of this block ranges from about 10 feet (3 m) to 30 feet (9 m). Most of the West Block is supplied with the groundwater withdrawn in each area. Only in Hlaingthaya, the groundwater supply will be supplemented by surface water from the Central Block. A transmission main from the Central Block is required for this township.



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Three (3) Blocks

FIG 4.16

(3) Zoning and water demand

1) Zoning and facility location

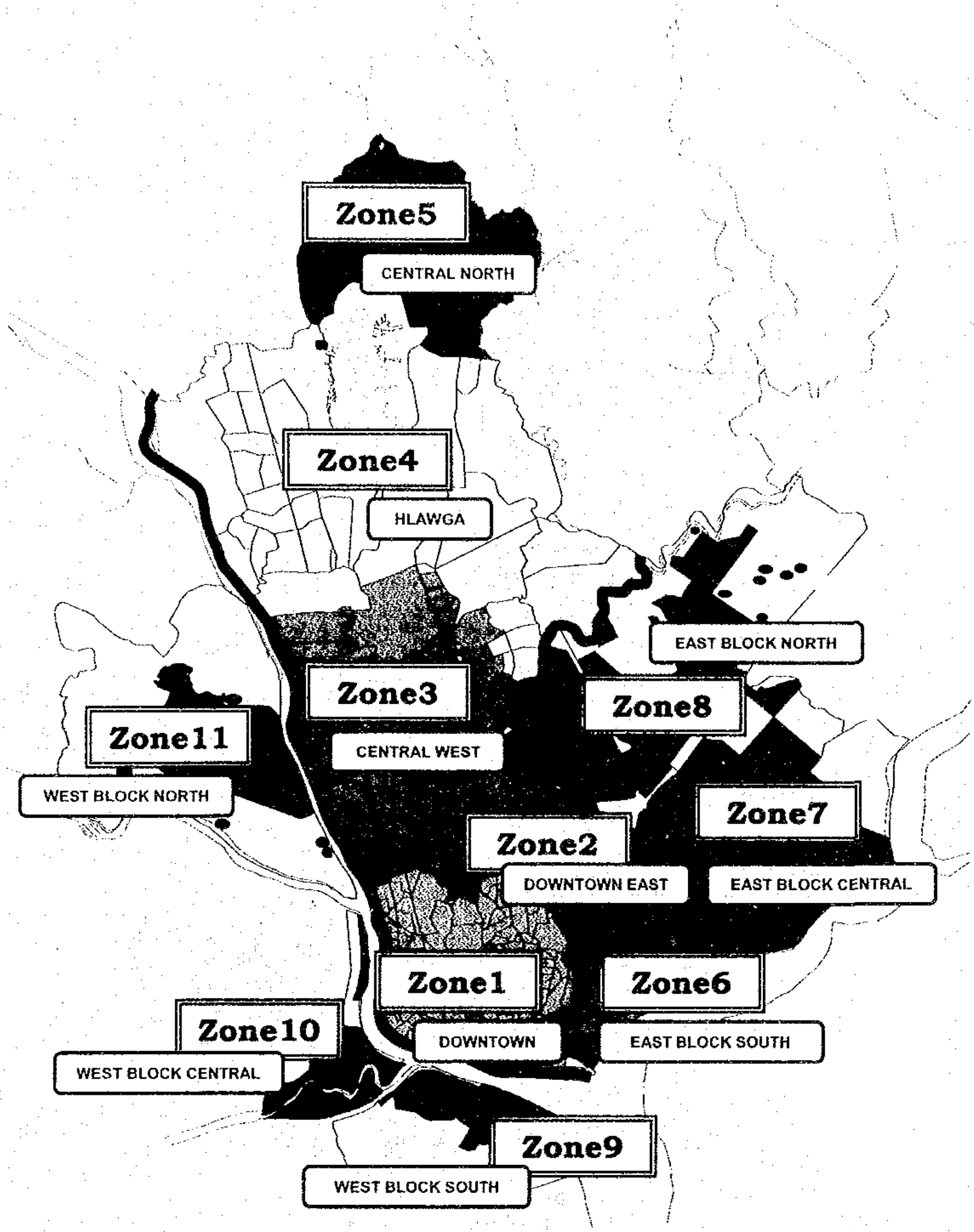
Based on the conditions and concepts stated above, the total Yangon City is divided into 11 zones (see Figure 4.17).

Water demand in 2020 and required service reservoir capacity of each zone is shown in Table 4.32.

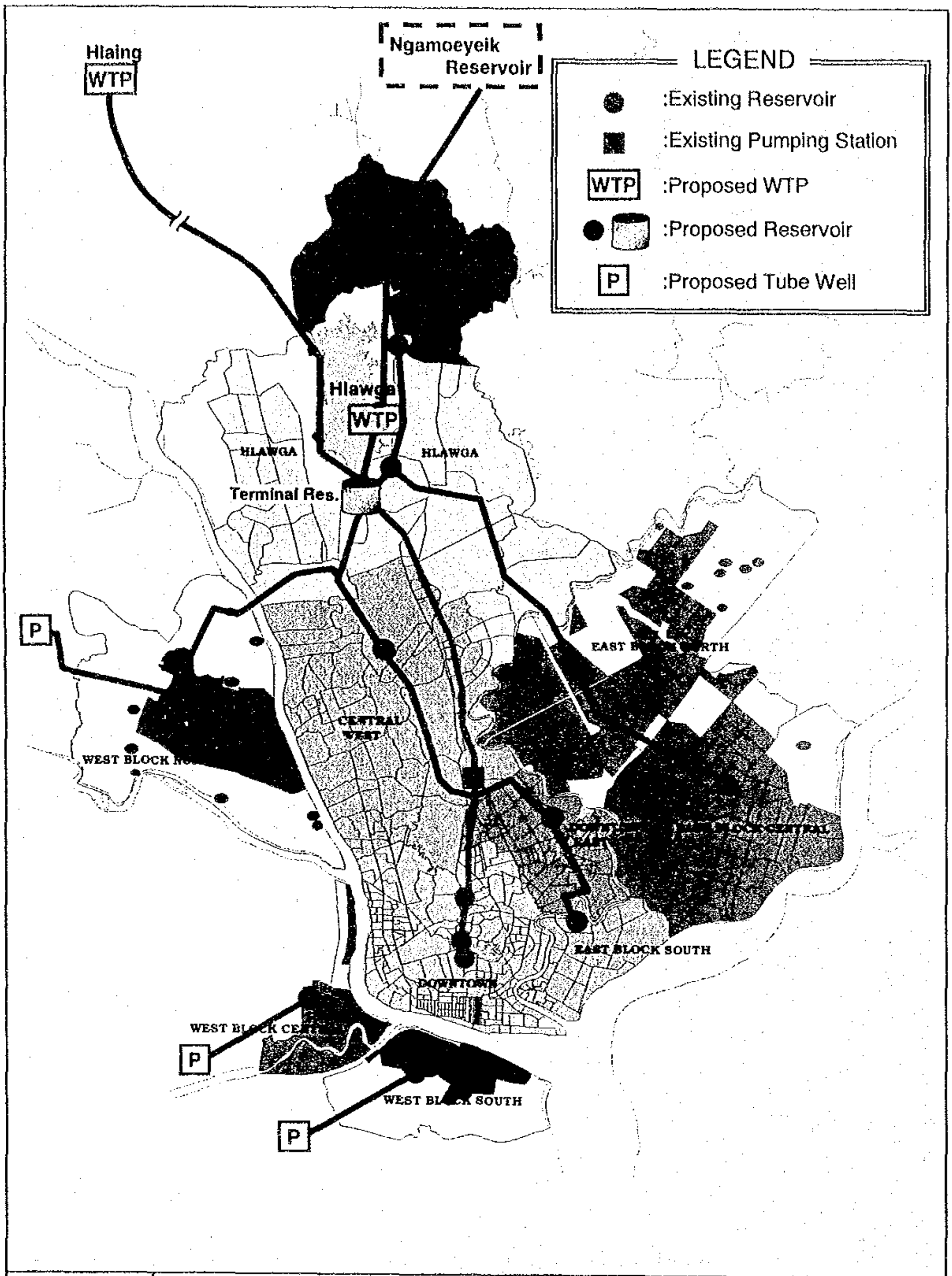
Table 4.32 Water Demand and Service Reservoir Capacity in Eleven (11) Zones

Block	Distribution Zone		Average water demand in 2020	Maximum water demand in 2020	Service Reservoir Capacity
	Name	No.	m^3/day	m^3/day	m^3
Central	Downtown	1	376000	451,000	141,500(Exist)
	Downtown East	2	271000	326,000	100,000
	Central West	3	243000	291,000	100,000
	Hlawga	4	262000	325,000	100,000
	Central North	5	29000	34,000	10,000
East	East South	6	121000	145,000	50,000
	East Central	7	111000	133,000	50,000
	East North	8	52000	62,000	50,000
West	West South	9	20000	25,000	10,000
	West Central	10	20000	24,000	10,000
	West North	11	81000	97,000	30,000
			1,586,000	1,913,000	621,500

The location of service reservoirs and route of transmission mains are proposed as shown in Figure 4.18. Figure 4.19 shows elevation of proposed facilities. Figure 4.18 and 4.19 shows the essence of the proposed facilities in this Master Plan. Then, Chapter 5 explains facilities plan more detail.



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 4.17
	Eleven (11) Zones	



JICA	THE STUDY ON IMPROVEMENT OF WATER SUPPLY SYSTEM IN YANGON CITY IN THE UNION OF MYANMAR	FIG 4.18
	Proposed Facilities	

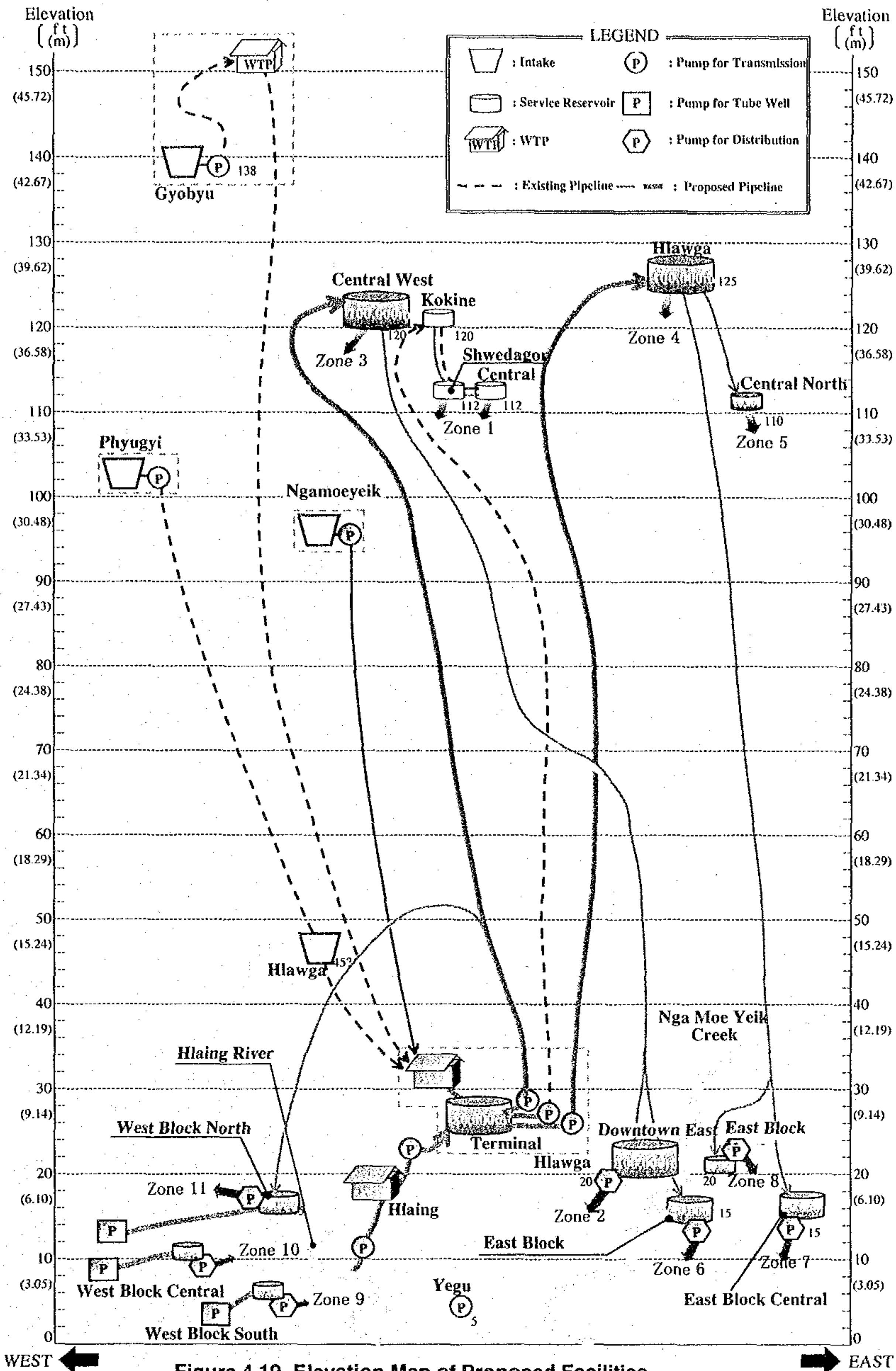


Figure 4.19 Elevation Map of Proposed Facilities