high, it is hard to open and close by hand. Accordingly, the washing has not been practiced sufficiently.

The major features of the above mentioned three Water Treatment Plants are summarized in Table-5.2.

5.3.2 Mae Rim and San Kamphaeng

1) Mae Rim

The Mae Rim Treatment Plant is located on the hill about 2 Km west of highway No. 107 and intake site is located close to a rivulet of Ram Nam Me Sa River about 0.9 Km further from the plant. The plant comprises an old facility of 80 m/h capacity and a new one of 250 m/h capacity. The layout is shown in Fig-5.9 and the major features of the Treatment Plant are summarized in Table-5.3 together with those of the San Kamphaeng Plant.

The above two facilities were designed based on the PWA standards and as the result of treated water quality testing, it has been proved that the water quality meets the DWS satisfactorily. As each facility has been periodically checked and maintained, there has been no noticeable mechanical failure. Chlorination has been applied without controlling the dosing rate and measuring the residual chlorine.

2) San Kamphaeng

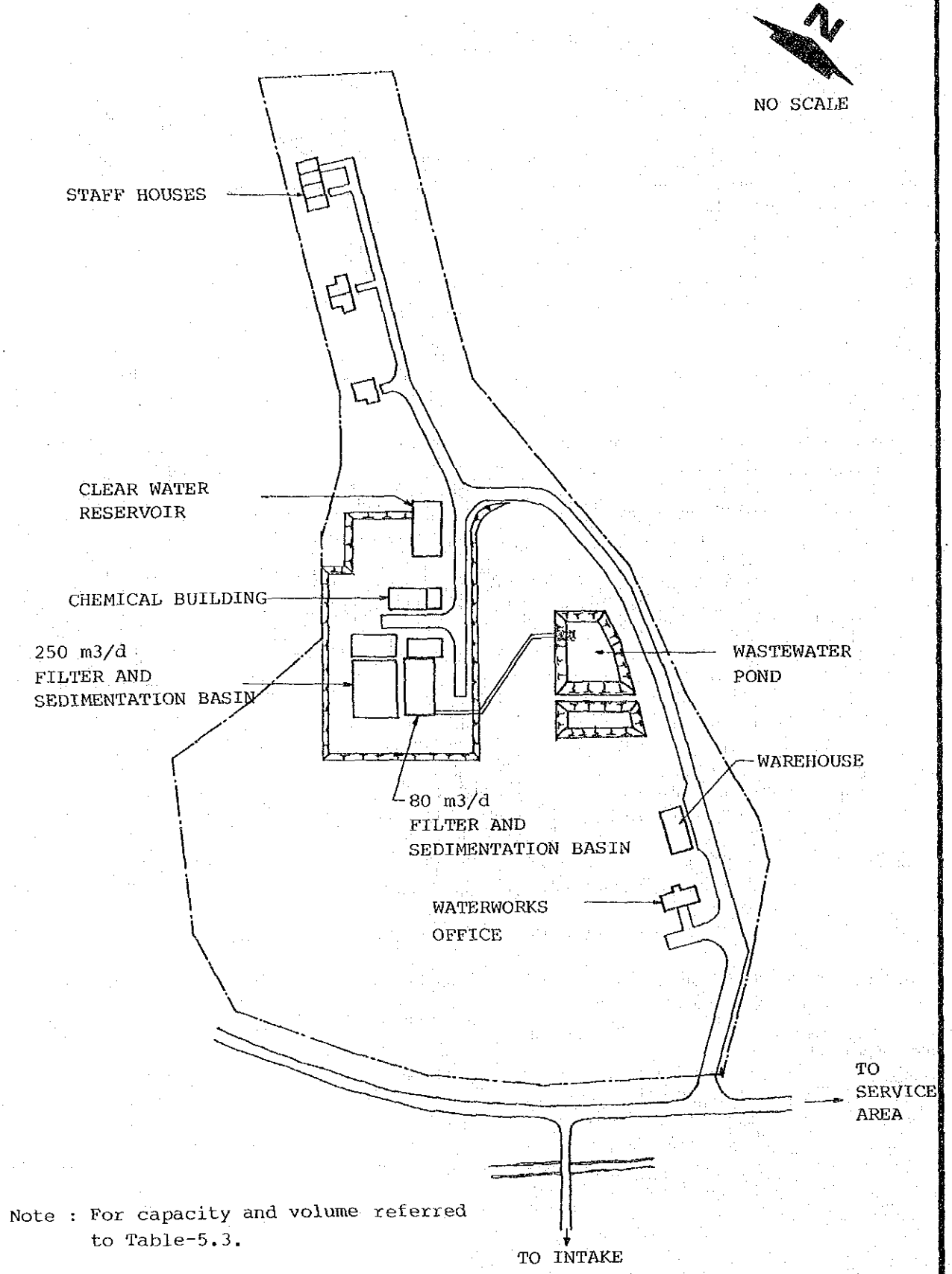
This treatment plant is located in a quiet place facing the main road using connecting to Chiangmai Municipality. The plant, constructed in 1970, is deep wells. The aeration system and treatment facilities of 80 cu m/h (= 1,920 cu m/d) were added to the plant because iron and manganese contents of raw water were found to be high eventually. The layout is shown in Fig-5.10.

The condition of facilities are more or less same as those in the Mae Rim Treatment Plant. The measuring device of the chlorine container's weight is also lacking.

Table-5.2 OUTLINE OF THREE TREATMENT PLANTS IN CHIANGMAI WATERWORKS

ITEM	WANG SING KAM TREATMENT PLANT	UMONG TREATMENT PLANT	PATON TREATMENT PLANT
Water Source	Ping River (Ban Tho Intake)	Mae Tang Irrigation canal	Ping River (Ban Tho Intake)
Capacity	(1) 80 m3/h (2) 250 m3/h	(1) 250 m3/h (2) 1,000 m3/h	660 cu m/h
Facilities			
- Receiving Well		(2) 1 basin (2) Detention time = 6.5 min.	1 well V=183 cu m Retention time=17 min.
- Flocculation Basin	(1) Horizontal zigzag flow (1) 1 basin (1) V = 40 m3 (1) Detention time = 30 min. (2) Vertical zigzag flow (2) 2 basins (2) V = 50 m3/basin (2) Detention time = 24 min.	(1) Vertical zigzag flow (1) 2 basin (1) V = 50 m3/basin (1) Detention time = 24 min. (2) Horizontal Flocculators (2) 4 basins (2) V = 250 m3/basin (2) Detention time = 60 min.	Vertical Flocculators 4 basins V=103 cu m/basin Retention time=37 min.
- Sedimentation Basin	(1) Horizontal flow (1) 1 basin (1) V = 350 m3 (1) Detention time = 4.3 hrs (2) Horizontal flow (2) 2 basins (2) V = 340 m3/basic (2) Detention time=2.7 hrs	(1) Horizontal flow (1) 2 basins (1) V = 340 m3/basin (1) Detention time = 2.7 hrs (2) Horizontal flow (2) 2 basins (2) V = 2,680 m3/basin (2) Retention time=5.4 hrs	Horizontal flow 2 basins V=1,080 cu m/basin Retention time=3.3 hrs
- Filter Bed	(1) 2 beds (1) Filtration rate=3.8 m3/hr/m2 (2) 5 beds (2) Filtration rate=3.8 m3/hr/m2	(1) 5 beds (1) Filtration rate=3.8 m3/hr/m2 (2) 8 beds (2) Filtration rate=3.2 m3/hr/m2	6 beds Filtration rate=4.1 m3/hr/m2
- Clear Water Reservoir	V = 500 and 1,800 m3 Detention time 7.0 hrs	V = 1,800 and 6,000 m3 Detention time 6.2 hrs	V = 4,600 m3 Detention time 6.9 hrs
Chemical application			
Coagulant	Aluminium Sulfate	Aluminium Sulfate	Aluminium Sulfate
Alkaline	Calcium Hydroxide	Calcium Hydroxide	Calcium Hydroxide
Chlorine	Chlorine gas and Bleaching powder	Chlorine gas	Chlorine gas

Note : Umong Treatment Plant has a 200,000 cu m capacity



Note : For capacity and volume referred to Table-5.3.

FIGURE	LAYOUT OF MAE RIM TREATMENT PLANT
5.9	

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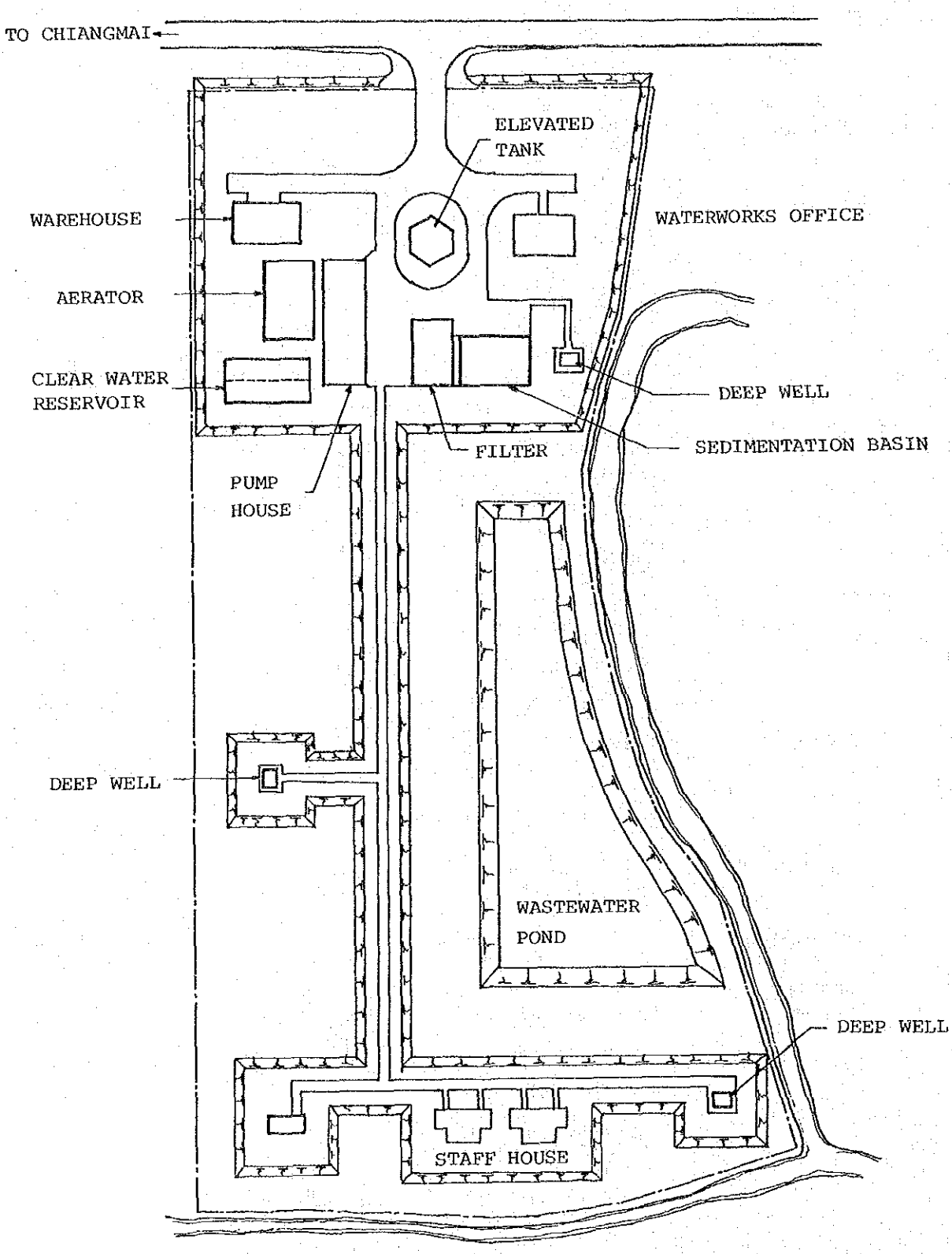
Tabel-5.3 OUTLINE OF MAE RIM AND SAN KAMPHAENG TREATMENT PLANTS

ITEM	MAE RIM TREATMENT PLANT	SAN KAMPHAENG TREATMENT PLANT
Water Source	Lam Nam Mae Sa (Tributary of Ping River)	Groundwater (Well depth 90m)
Capacity	(1) 80 m3/h (2) 250 m3/h	(1) 80 m3/h
Facilities		
- Flocculation Basin	(1) Vertical zigzag flow (1) 1 basin (1) V = 40 m3 (1) Detention time = 30 min. (2) Vertical zigzag flow (2) 2 basins (2) V = 50 m3/basin (2) Detention time = 24 min.	(1) Vertical zigzag flow (1) 1 basin (1) V = 40 m3 (1) Detention time = 30 min.
- Sedimentation Basin	(1) Horizontal flow (1) 1 basin (1) V = 350 m3 (1) Detention time = 4.3 hrs (2) Horizontal flow (2) 2 basin (2) V = 340 m3/basin (2) Detention time = 2.7 hrs	(1) Horizontal flow (1) 1 basin (1) V = 350 m3 (1) Detention time = 4.3 hrs
- Filter Bed	(1) 2 beds (1) Filtration rate=3.8 m3/hr/m2 (2) 5 beds (2) Filtration rate=3.8 m3/hr/m2	(1) 2 beds (1) Filtration rate=3.8 m3/hr/m2
- Clear Water Reservoir	V = 1,800 m3 Detention time = 5.5 hrs	V = 950 and 120 m3 Detention time = 7.6 hrs
Chemical aplication		
Coagulant	-	Aluminium Sulfate
Alkaline	-	Calcium Hydroxide
Chlorine	Chlorine gas and Bleaching powder	Chlorine gas



Note : For capacity and volume referred to Table-5.3.

FIGURE	LAYOUT OF SAN KAMPHAENG TREATMENT PLANT
5.10	

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5.4 Distribution Facilities

5.4.1 Chiangmai

Distribution pumps at the treatment plants lift water from clear water reservoir to pump it to the network. Corresponding to the fluctuating pattern of water demand, the number of distribution pumps put in operation is adjusted, so that the delivery pressures in the Paton and Umong Treatment Plant are maintained at lower than 2.8 and 2.0 kg/sq cm respectively.

According to the questionnaire survey, most of the service area, except in and around the high elevation area near the Umong Plant, is pressurized satisfactorily, as the answer complaining of low pressure was about 8 %. However, when the Umong Plant was suspended of its operation, the nearby area's people experienced poor supply.

Table-5.4 (1) shows the distribution pipelines, classified by size and material. The asbestos cement pipes (ACO) are, in size, less than 300 mm and include more than 15 years old Class 10 and 12 (low pressure service) and Class 15 laid in recent years.

The network shown in Fig-5.11 covers most of the areas of high demand and naturally larger size pipes are used in the central parts of the Municipality. As shown in the same figure, a 300 mm pipeline is connected with Mae Rim water supply system.

About 140 valves for controlling distribution and about 120 fire hydrants for protection against fire are located at the strategic points and air valves are installed mainly on pipe bridges, the peak points in the pipelines' profile.

The house-connections, numbering about 15,700 as of September 1985, are mostly provided with a water meter and stop valve.

Table-5.4.(1) DIAMETER AND LENGTH OF EXISTING PIPELINE
CHIANGMAI WATERWORKS

Dia. (mm)	Material	Length (m)
500	Ductile iron	5,000
450	- do -	1,000
400	- do -	6,000
350	- do -	3,000
300	Asbestos cement	17,000
250	- do -	4,000
200	- do -	21,000
150	- do -	31,000
100	- do -	16,000
TOTAL		104,000

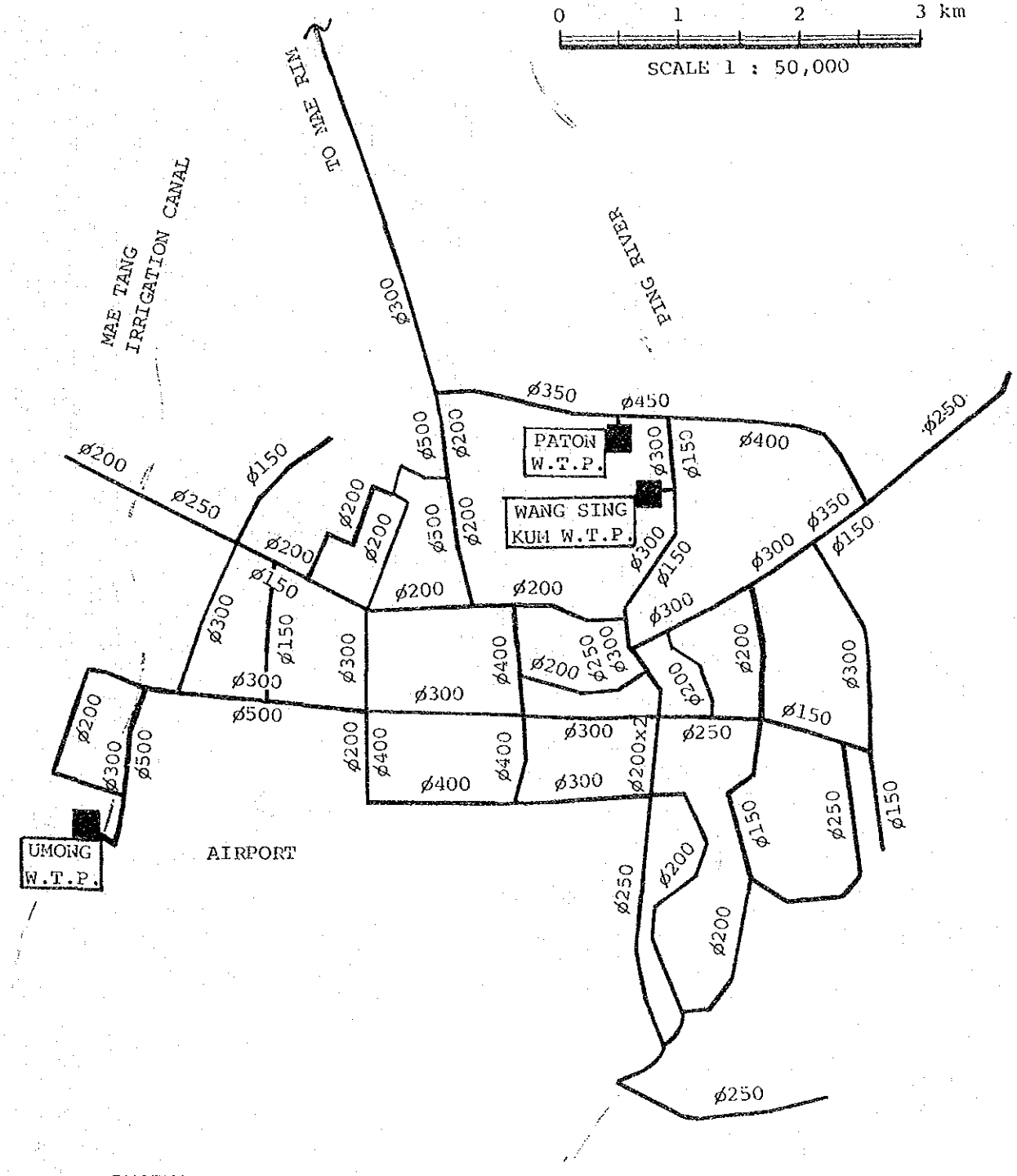
5.4.2 Mae Rim and San Kamphaeng

1) Mae Rim

As the treatment plant and distribution reservoir are located on a low hill, higher the service area in elevation, treated water is delivered by gravity.

Table-5.4 (2) shows the distribution pipelines, classified by size. The 300 mm diameter, 10.4 km long pipeline is laid along the Main Road 107 and connected to the distribution network of the Chiangmai Waterworks. The 300 mm dia, pipeline serves the large consumers such as the army camp, Chiangmai Hospital and Land Development Office located along the route. The rest consisting of 100 to 250 mm diameter, 12 km long in total, is arranged as shown in Fig-5.12.

About 40 valves and 30 fire hydrants are installed at the strategic points of the distribution networks. There are about 800 house connections ranging from 1/2 to 6 inches.



LEGEND

W.T.P. : WATER TREATMENT PLANT

FIGURE	EXISTING DISTRIBUTION PIPELINES (CHIANGMAI)
5.11	

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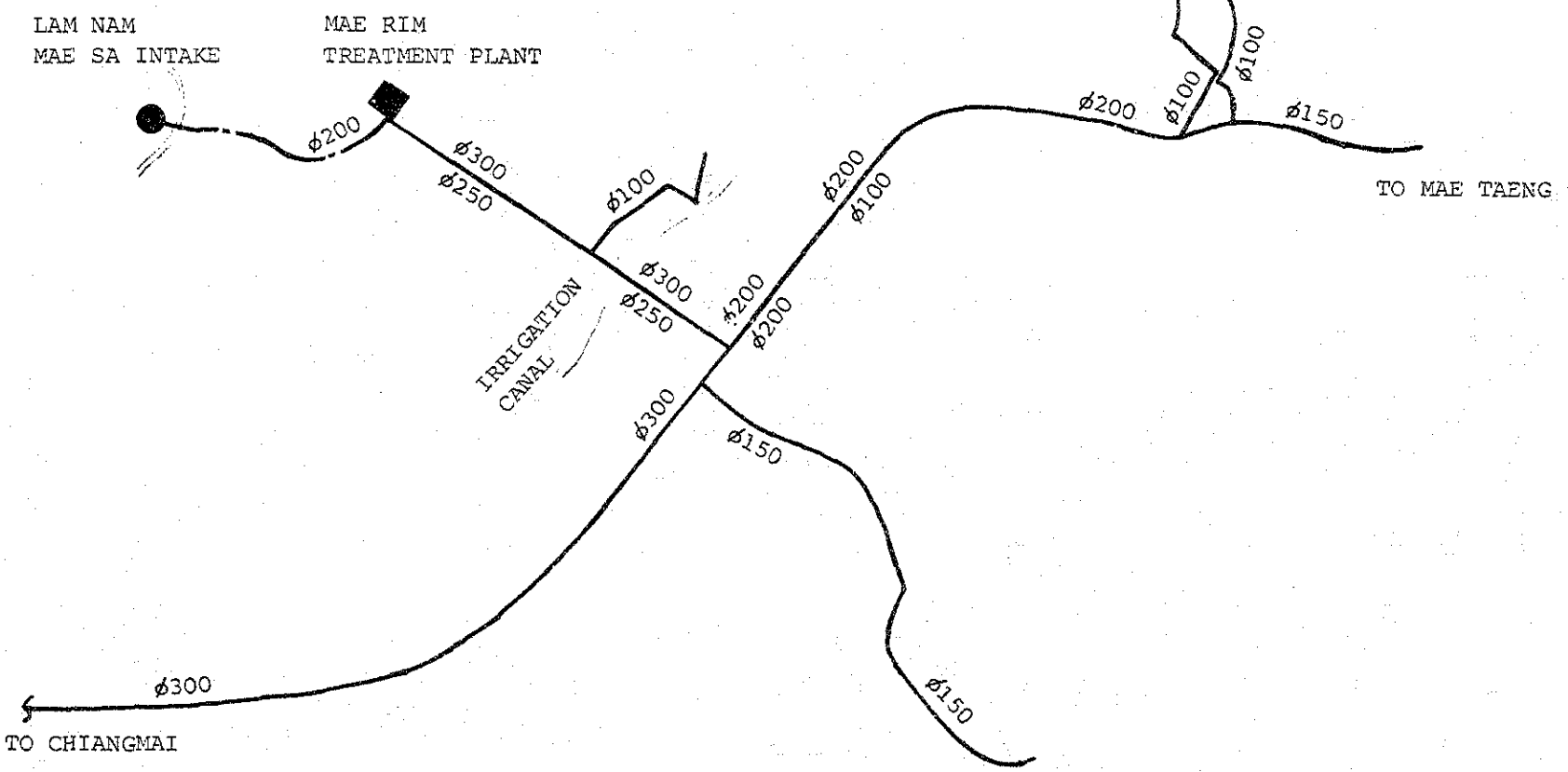

FIGURE	EXISTING DISTRIBUTION PIPELINES (MAE RIM)
5.12	

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2) San Kamphaeng

Treated water is pumped to the elevated tank and delivered therefrom to the service area by gravity. the ACP of 100 to 200 mm in diameter and 22 km long in total, as listed in Table-5.4 (2), is laid as shown in Fig-5.13 and 25 valves and 18 hydrants are installed. House connections totaled about 1,400 at the end of 1985. The meter diameter ranges from 1/2 to 3 inches and more than 90 % of the smallest size of 1/2 inch.

Table-5.4 (2) DIAMETER AND LENGTH OF EXISTING PIPELINE

SANITARY DISTRICTS

Dia. (mm)	Pipe Length (m) MAE RIM	SAN KAMPHAENG
300	10,400	
250	1,400	
200	3,000	3,000
150	2,500	6,000
100	5,000	13,000
TOTAL	22,300	22,000

Note: All pipe material of the Sanitary Districts are Asbestos cement pipe.

5.5 Rehabilitation and Modification Works

The facilities described heretofore are planned for use in future.

To prepare for the future increase of water demand, rehabilitation and modification of the existing facilities are of absolute necessity as well as expansion of them.

The planned rehabilitation, modification and expansion works will be detailed in Chapter 7 later.

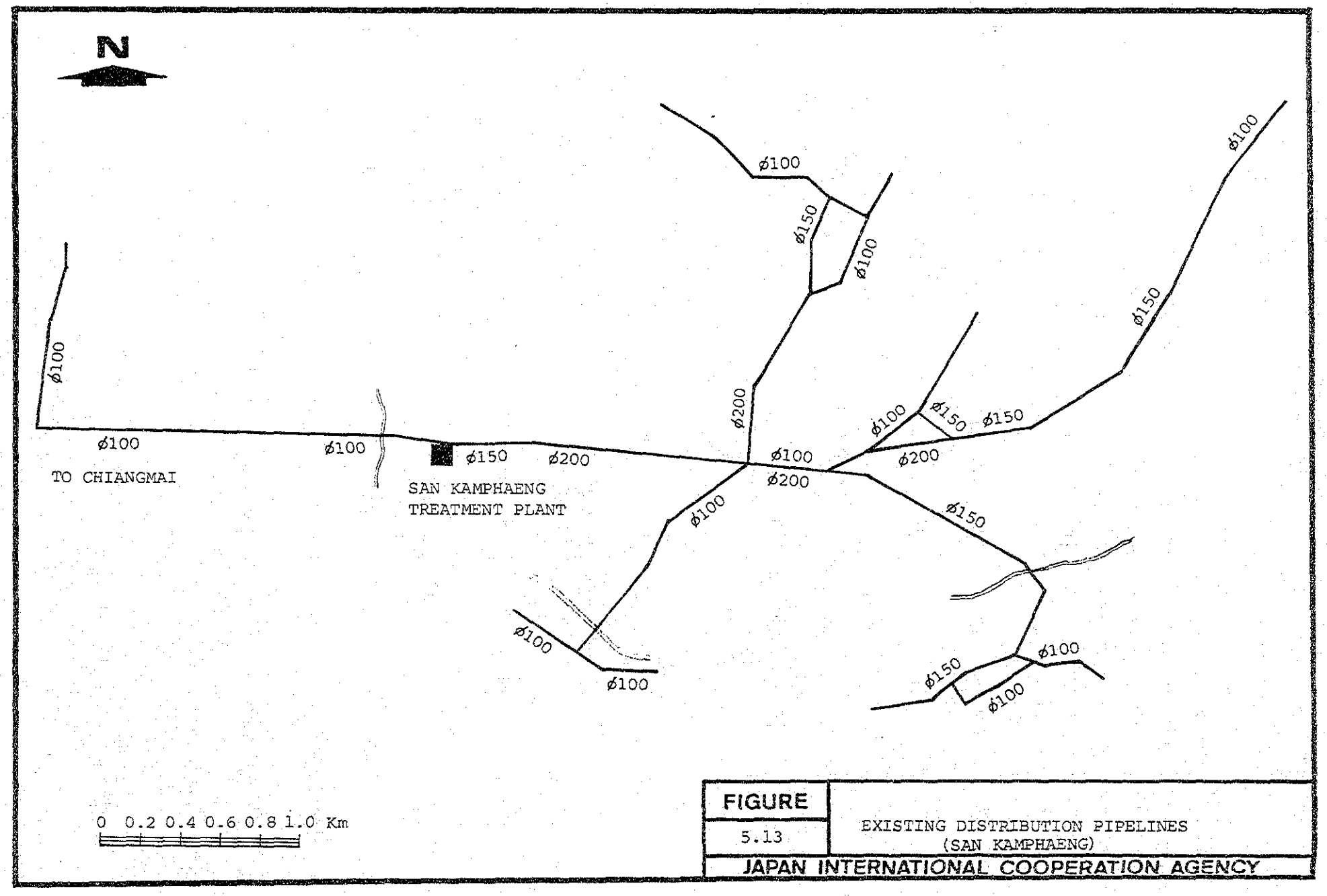

FIGURE	
5.13	EXISTING DISTRIBUTION PIPELINES (SAN KAMPHAENG)

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Chapter 6 POPULATION AND WATER DEMAND

CHAPTER 6

Chapter 6 POPULATION AND WATER DEMAND

6.1 General

This chapter deals with the future population and water demand of the service area comprising, as defined in the scope of work, Chiangmai Municipality, and San Sai, San Kamphaeng, Saraphi, Hang Dong and Mae Rim Sanitary Districts.

The future water demands were estimated based on analyzing the served populations and the water consumption records provided by PWA. The past trend was studied for each category of water uses, such as domestic, government, commercial and industrial and the future water demands were estimated category-wise. Since the major economy of the Municipality is tourism, the water requirements by tourism are also analyzed and included in the forecast. For forecasting the future population and water demand, PWA Design Criteria was also referred and taken into consideration.

For the details of the forecast, refer to Appendix 1 POPULATION FORECAST and Appendix 2 FUTURE WATER DEMAND.

6.2 Population

6.2.1 Past trend of population

The records of populations of Chiangmai and the five sanitary districts for last the 10 years are summarized in Table-6.1.

The past trend of Chiangmai shows stable increase of 2 % per year on an average except adjustment by census results in 1980 and incorporation of surrounding areas in 1983.

The five sanitary districts showed an average population increase at 5.6 % per year for last the 10 years.

Table-6.1 PAST POPULATION

YEAR	CHIANGMAI POP.	RATIO	MAE RIM POP.	RATIO	SAN KAMPHAENG POP.	RATIO	SAN SAI POP.	RATIO	SARAPHI POP.	RATIO	HANG DONG POP.	RATIO	TOTAL POP.	RATIO
1975	100,837		9,502		14321		2,683		7,698		3,007		138,048	
		0.037		0.120		0.165		4.262		0.000		0.500		0.146
1976	104,519		10,640		16689		14,118		7,697		4,512		158,175	
		0.007		-0.014		0.003		0.004		0.009		0.045		0.006
1977	105,230		10,486		16746		14,179		7,770		4,715		159,126	
		0.015		0.002		0.004		0.004		0.021		0.022		0.013
1978	106,836		10,511		16814		14,231		7,931		4,821		161,144	
		-0.084		0.003		-0.113		0.565		-0.618		0.010		-0.048
1979	97,839		10,545		14920		22,273		3,026		4,867		153,470	
		0.024		-0.001		0.007		0.004		1.653		0.009		0.049
1980	100,146		10,538		15018		22,363		8,029		4,913		161,007	
		0.012		0.002		-0.004		-0.028		0.037		0.009		0.006
1981	101,394		10,559		14962		21,744		8,325		4,959		161,343	
		0.028		0.041		-0.023		0.006		-0.001		0.001		0.019
1982	104,190		10,993		14622		21,884		8,314		4,962		164,965	
		0.444		-0.005		0.105		0.004		0.027		0.014		0.292
1983	150,499		10,939		16156		21,964		8,540		5,031		213,129	
		0.020		-0.010		0.035		0.004		0.020		-0.030		0.017
1984	153,537		10,831		16720		22,050		8,707		4,881		216,726	
		0.013		0.023		0.014		0.004		0.030		-0.009		0.013
1985	155,471		11,084		16953		22,148		8,965		4,836		219,457	

6.2.2 Population Forecast

The population growth models are examined in the present study and the most probable model is adopted to forecast future population of each district of the service area.

Chiangmai is envisaged to increase its population at 2 % per year, a rate observed for the last 10 years. Future populations of each of the five sanitary districts are separately estimated. The population forecasts are summarized in Table-6.2.

Table-6.2 POPULATION OF THE PROJECT AREA

AREA	1985	1990	1995	2000	2050	2010
CHIANGMAI	155,000	164,000	173,000	181,000	190,000	199,000
MAE RIM	11,100	11,600	12,000	12,600	13,100	13,600
SAN KAMPHAENG	17,000	18,800	20,600	22,400	24,200	26,100
SAN SAI	22,200	22,700	23,200	23,700	24,200	24,700
SARAPHI	8,800	9,600	10,300	11,100	12,000	13,000
HANG DONG	5,200	5,500	5,800	6,100	6,400	6,700
TOTAL	219,300	232,200	244,900	256,900	269,900	283,100

6.3 Service Area and Served Population

6.3.1 Service Area

As the waterworks of Chiangmai, Mae Rim and San Kamphaeng are under the control of PWA, the present service area is defined to be consisting of the service area of Chiangmai Waterworks and the two sanitary districts. In Chiangmai, the service area is almost identical to the municipality's administrative area.

Until 2000 the present status will be kept, while the service area is expected to expand in the municipality and sanitary districts

San Sai and Saraphi, presently lacking water supply service, will have to establish their own system in near future and Hang Dong, presently served by a small system will have to expand the system.

After 2000, the present PWA service are will be linked to the service area of San Sai and Saraphi possibly, though Hang Dong's will be remain isolated.

The present and future service area is presented on Fig-6.1.

6.3.2 Served Population

The future population to be served by the planned water supply system, will be projected, taking into consideration of the population growth, expansion of the service area, socio-economic conditions and availability of alternative water source.

The projected served populations is tabulated in Table-6.3.

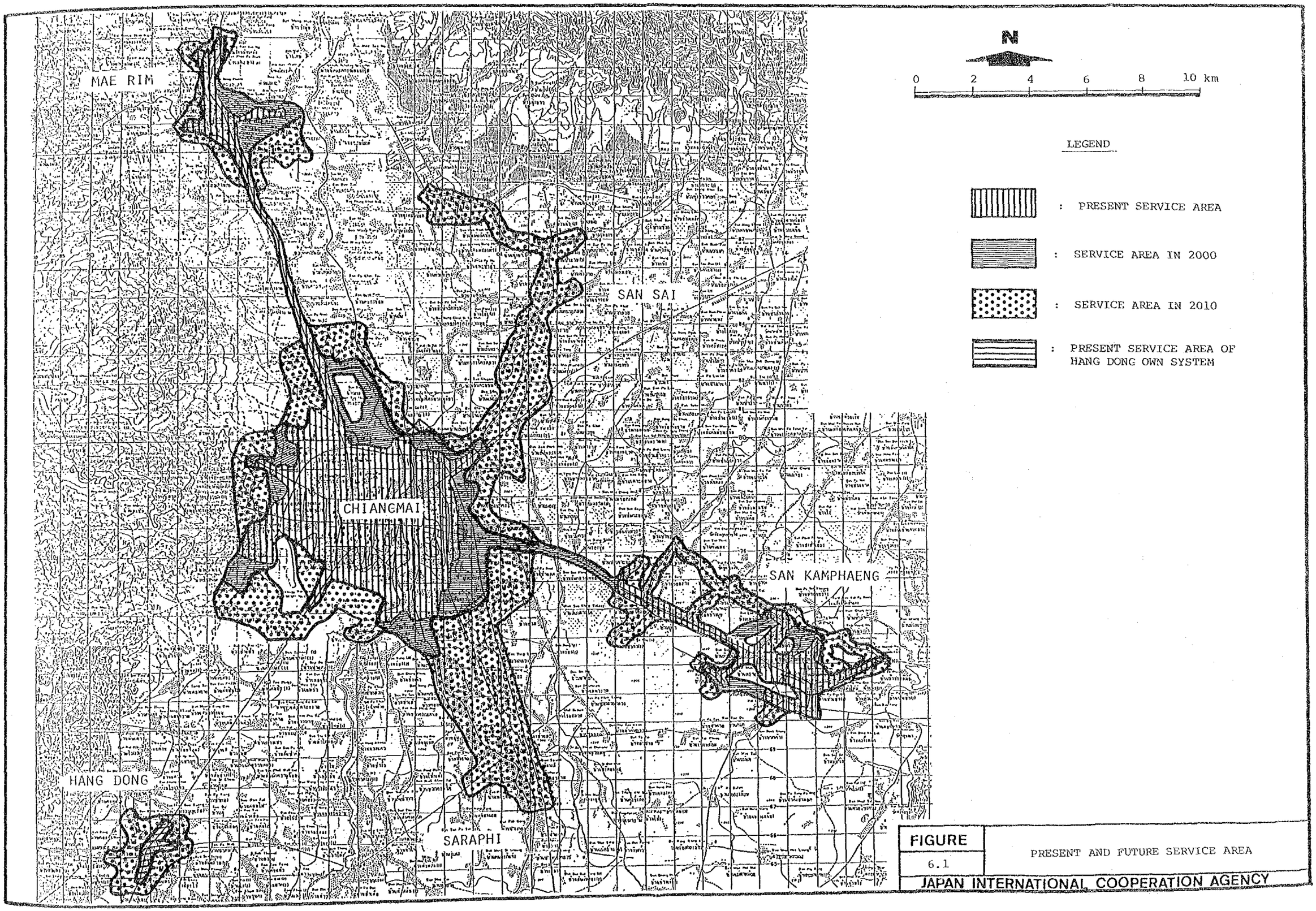

FIGURE 6.1 PRESENT AND FUTURE SERVICE AREA

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Table-6.3 FUTURE SERVED POPULATIONS

Description	1985	1990	1995	2000	2005	2010
Chiangmai						
- Population	155,000	164,000	173,000	181,000	190,000	199,000
- Served Ratio (%)	52	61	67	70	73	75
- Served Population	80,600	100,040	115,910	126,700	138,700	149,250
Mae Rim						
- Population	11,084	11,600	12,000	12,600	13,100	13,600
- Service Ratio (%)	42	53	61	65	68	70
- Served Population	4,655	6,148	7,320	8,190	8,908	9,520
San Kamphaeng						
- Population	17,000	18,800	20,600	22,400	24,200	26,100
- Service Ratio (%)	34	43	50	57	62	65
- Served Population	5,780	8,084	10,300	12,768	15,004	16,965
San Sai						
- Population	22,200	22,700	23,200	23,700	24,200	24,700
- Service Ratio (%)	0	15	27	36	44	50
- Served Population	0	3,405	6,264	8,532	10,648	12.350
Saraphi						
- Population	8,800	9,600	10,300	11,100	12,000	13,000
- Service Ratio (%)	0	15	27	36	44	50
- Served Population	0	1,440	2,781	3,996	5,280	6,500
Hang Dong						
- Population	5,200	5,500	5,800	6,100	6,400	6,700
- Service Ratio (%)	0	15	27	36	44	50
- Served Population	0	825	1,566	2,196	2,816	3,350
Total Served Population	91,035	119,942	144,141	162,382	181,356	197,935

6.3.3 Tourist Forecast

The number of tourists in the future shall be studied, as it will certainly affect the water demand. The forecasted number, however, is not to be included in the population but to be used in estimating the water demand by tourism.

For forecasting the tourist's number, the study team held discussions with TAT, DTCP, and the Municipal Office. The discussions and previous study reports on the tourism sector are reflected in the forecasts. Annual tourist forecasts are shown in Table-6.4.

Table-6.4 TOURIST FORECAST

Year	Annual visits of Tourists (persons/year)	Average Length of Stay	Average Daily Tourists (persons/day)
1983	534,005	3	4,389
1984	561,150	3	4,612
1985	591,597	3	4,862
1990	733,364	3	6,028
1995	862,560	3	7,090
2000	983,002	3	8,079
2050	1,096,833	3	9,015
2010	1,205,411	3	9,907

(Average Daily Tourists) = (Annual Visits of Tourists)
x (Average Length of Stay)/365

6.4 Water Demands

The study of water demands is detailed in APPENDIX 2 attached to this report.

In this sub-section, the water consumption classified by categorized consumer groups of Chiangmai is forecasted. Following it, the unaccounted-for ratio and the peak factor, ratio of the maximum to average day consumption, are estimated.

Using the above data, the maximum and average day demands of Chiangmai are calculated, tabulated and plotted in a figure.

The same process is applied to the five sanitary districts.

6.4.1 Chiangmai

Table-6.5 shows the water consumption classified by categorized consumer groups. Each of the five categories' consumption is expressed in terms of per capita. The percentage of use shows the non-revenue water accounts for 34 % of the total and the percentage to total consumption is the ratio of each consumption to the total, revenue-bearing water.

1) *Domestic Water Consumption*

The domestic water consumption is estimated on the per capita basis. It is at 143 lpcd in 1985. The future per capita consumption is assumed to gradually increase to 185 lpcd in 2000 and 210 lpcd in 2010. From the assumed per capita consumption and estimated served population, the future domestic water consumption is estimated, as shown in Table-6.6.

2) Commercial Water Consumption

This category includes consumptions at restaurants, bars and shops.

This consumption is projected to allow a growth proportional to the domestic consumption, and estimated as shown in Table-6.7.

Table-6.5 PRESENT PER CAPITA CONSUMPTION

Water Use Category	Per Capita (lpcd)	Percentage of use (%)	Percentage to Total Consumption
1) Domestic	143	32.1	48.6 %
2) Commercial	9	2.0	3.0 %
3) Institutional	119	26.7	40.5 %
4) Tourism	6	1.4	2.1 %
5) Others	17	3.8	5.8 %
Total 1) - 4)	294	66.0	100.0 %
Non-Revenue Water	151	34.0	-
Total Demand	445	100.0	-

Note: * Based on the served population of 80,600 in Sep. 1985.

Table-6.6 DOMESTIC WATER CONSUMPTION

YEAR	SERVED POPULATION	PER CAPITA CONSUMPTION (lpcd)	DOMESTIC WATER CONSUMPTION (cu m/day)
1985	80,600	143	11,500
1990	100,040	155	15,500
1995	115,910	170	19,700
2000	126,700	185	23,400
2005	138,700	200	27,700
2010	149,250	210	31,300

Table-6.7 COMMERCIAL WATER CONSUMPTION

YEAR	SERVED POPULATION	UNIT CONSUMPTION (lpcd)	COMMERCIAL CONSUMPTION (m3/day)
1985	80,600	9	720
1990	100,040	10	1,000
1995	115,910	11	1,280
2000	126,700	12	1,520
2005	138,700	13	1,800
2010	149,250	14	2,090

3) Institutional Water Consumption

This category includes such consumers as the government offices, hospitals, schools, and temples. This consumption, as it is already high, is assumed to grow scarcely and estimated as shown in Table-6.8.

Table-6.8 INSTITUTIONAL WATER CONSUMPTION

YEAR	UNIT CONSUMPTION (lpcd)	INSTITUTIONAL CONSUMPTION (m3/day)
1985	119	9,550
1990	119	11,900
1995	120	13,910
2000	121	15,310
2005	121	16,790
2010	121	18,060

4) Tourism Water Consumption

This category includes consumptions at hotels, bungalows and massage parlors and accounts for about 2 % of the total consumption.

2 % is unbelievably low for a popular resort area of Chiangmai. The reason is that those tourism-related establishments use much groundwater, drawn from individual deep wells. The Chiangmai waterworks estimate that only 15 % of their consumption is relied on the waterworks supply while the rest, major part, the groundwater.

The present situation is assumed to change in future, as the waterworks supply will gradually replace the groundwater to make the present ratio to 65 % in 2000 and 90 % in 2010.

Table-6.9 shows the tourism water consumption, calculated from the tourist number per day per capita consumption, estimated consumption including all supply sources, reliance ratio on PWA water and, finally, demand on PWA water.

5) Others Water Consumption

This category comprises consumptions of other users than the categorized before. It includes domestic-size industry and suchlike.

PWA survey in 1985 indicated that the consumption was about 1,400 m3/day, or 17 lpcd. This demand is assumed to gradually increase up to 29 lpcd by 2010.

Table-6.9 TOURISM WATER CONSUMPTION

Classification	Year					
	1985	1990	1995	2000	2005	2010
Tourist Number per day	4,862	6,028	8,079	8,079	9,015	9,907
Per Capita (lpcd)	700	700	750	750	750	750
Estimated Consumption incl. PWA water and others (cu m/d)	3,404	4,219	5,317	6,060	6,761	7,431
Reliance Ratio on PWA Water (%)	15	25	45	65	80	90
Demand on PWA Water (cu m/d)	515	1,055	2,392	3,939	5,409	6,688

6) Total Water Consumption

Table-6.10 presents a summary of water consumptions by categories and per capita consumption.

7) Unaccounted-for Water

The leakage and other forms of unaccounted-for water are currently estimated at 32 % of the average day demand presently.

In projecting the future unaccounted-for ratio, therefore, planned reduction of leakage by rectifying the above conditions and promoting leakage control programs shall be taken into account.

The planned future ratio of the unaccounted-for is listed in Table-6.11.

Table-6.10 TOTAL WATER CONSUMPTION
(CHIANGMAI)

YEAR	SERVED POPULATION	RESIDENTIAL PER CAPITA (lpcd)	RESIDENTIAL CONSUMPTION (cu m/d)	COMMERCIAL PER CAPITA (lpcd)	COMMERCIAL CONSUMPTION (cu m/d)	INSTITUTIONAL PER CAPITA (lpcd)	INSTITUTIONAL CONSUMPTION (cu m/d)	TOURISM PER CAPITA (lpcd)	TOURISM CONSUMPTION (cu m/d)	OTHERS PER CAPITA (lpcd)	OTHERS CONSUMPTION (cu m/d)	TOTAL CONSUMPTION (cu m/d)
1985	80,600	143	11,500	9	720	119	9,550	6	440	17	1,330	23,500
1990	100,040	155	15,500	10	1,000	119	11,900	11	1,100	19	1,900	31,400
1995	115,910	170	19,700	11	1,280	120	13,910	20	2,320	22	2,550	39,800
2000	126,700	185	23,400	12	1,520	121	15,310	31	3,920	24	3,040	47,100
2005	138,700	200	27,700	13	1,800	121	16,790	39	5,410	27	3,750	55,500
2010	149,250	210	31,300	14	2,090	121	18,060	45	6,720	29	4,330	62,600

8) Average Day and Maximum Day Water Demand

The average day demand consists of the total water consumption estimated above and the unaccounted-for water. The maximum day demand as the average day demand multipled by the peak factor.

Table-6.11 and Fig-6.2 shows the average day and maximum day demands for Chiangmai.

Table-6.11 SUMMARY OF WATER DEMANDS
(CHIANGMAI)

Unit : cu m/d

Classification	1985	1990	1995	2000	2005	2010
Total Consumption	23,500	31,400	39,800	47,100	55,500	62,600
Unaccounted-for water	11,000	11,600	13,300	14,100	14,800	15,700
Unaccounted-for ratio	32 %	27 %	25 %	23 %	21 %	20 %
Average Day Demand	34,400	43,000	53,100	61,200	70,300	78,300
Peak Factor*	1.25	1.25	1.25	1.25	1.25	1.25
Max. Day Demand	43,000	53,800	66,400	76,500	87,900	97,900

* Refer to Appendix 2

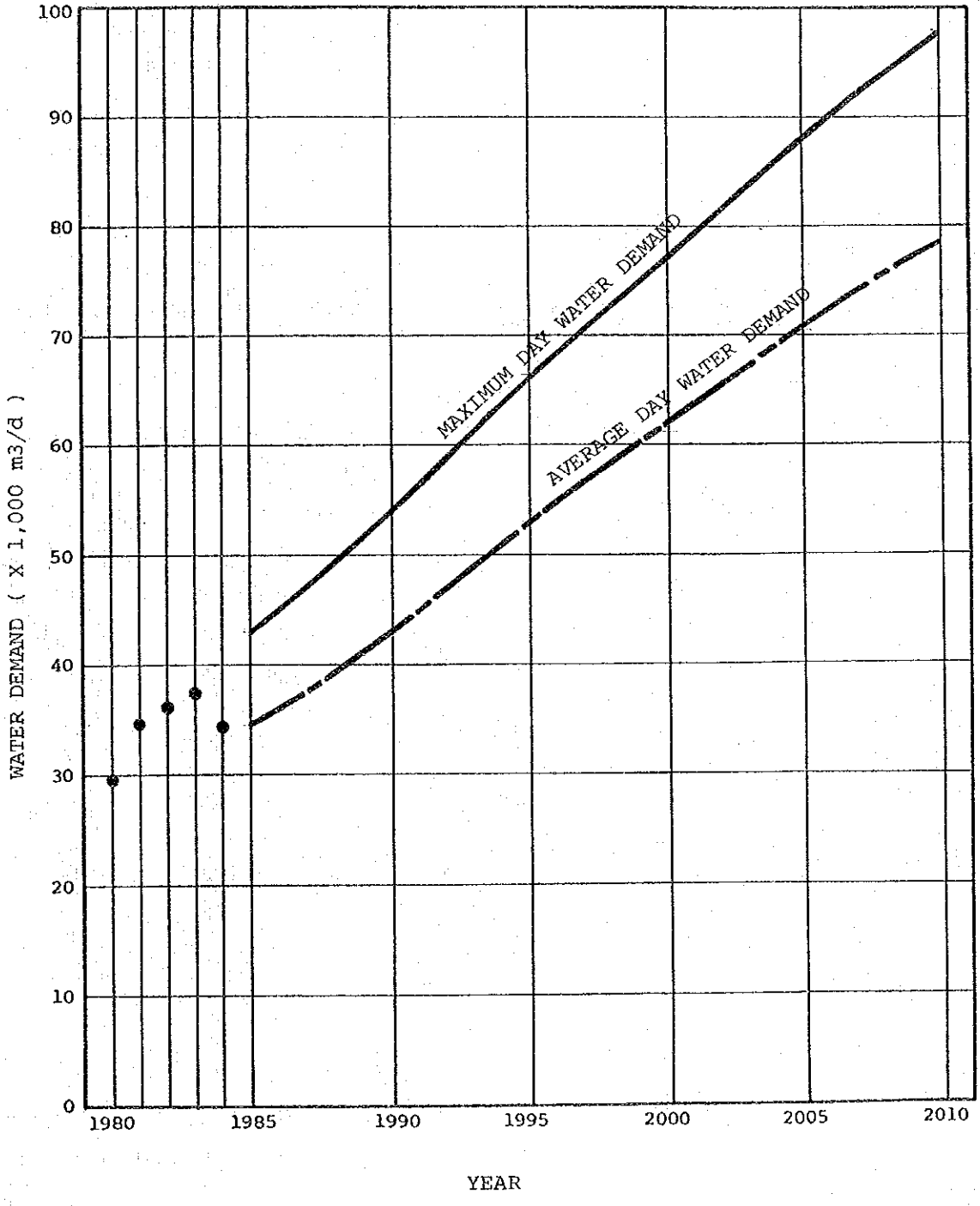

FIGURE 6.2	FUTURE AVERAGE DAY AND MAXIMUM DAY DEMAND OF CHIANGMAI

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6.4.2 Sanitary Districts

Mae Rim and San Kamphaeng are presently provided with public piped water supply, while San Sai, Saraphi and Hang Dong are planned to be served by PWA within the frame work of the project. The future water demands are forecast on the per-capita consumption basis.

1) Mae Rim

This sanitary district holds large-scale customers such as the army camp, Chiangmai Hospital, Land Development Office as well as a ceramic factory, industrial customer. These customers as Government/industries account for about 70 % of the total water consumption.

The domestic consumption is presently estimated at 80 lpcd. Future urbanization will cause increase in the water demands, and the per capita consumption is expected to increase to 103 lpcd by 2000 and 120 lpcd by 2010.

The category of "others" includes uses for commercial and domestic-size factories and is presently estimated at 50 lpcd. The urbanization in the area will result in growth of water demands up to 65 lpcd by 2000 and 75 lpcd by 2010.

2) San Kamphaeng

The water demand of the district consists of domestic and others consumptions. The both consumptions are expected as same level as Mae Rim.

3) San Sai, Saraphi and Hang Dong

PWA service will be initiated in these districts in 2000. The domestic consumption will be 98 lpcd in 2000, at 1985 level of Mae Rim, and gradually increase to 120 lpcd by 2010. The others consumption is expected at 60 lpcd in 2000, and to increase to 72 lpcd in 2010.

4) Unaccounted-for Water Ratio

The leakage and other forms of unaccounted-for water are forecast as described in Section 6.4.1. The ratio is estimated at 23 % in 2000 and 20 %

in 2010.

5) Average Day and Maximum Day Water Demand

As the total water consumption estimated above is the net delivery, the unaccunted-for water shall be added to it in computing the demand for production. The average day and maximum day demands are defined as the production demand here.

Table-6.12 and Fig-6.3 shows the average day and maximum day demand for the five sanitary districts.

Table-6.12 SUMMARY OF POPULATION AND WATER DEMAND

MAE RIM SANITARY DISTRICT

YEAR	POP.	SER. RATIO (%)	SERVED POP.	PER-CAPITA DEMAND (lpcd)	INDUSTRY DEMAND (lpcd)	OTHERS DEMAND (lpcd)	T O T A L DEMAND (lpcd)	(m3/day)	UN-ACCOUNT RATIO (%)	AVE-DAY DEMAND (m3/day)	PEAK FACTOR (1)	MAX-DAY DEMAND (m3/day)
1985	11,084	42	4,655	80	290	50	420	1,955	33	2,918	1.35	3,940
1990	11,600	53	6,148	87	292	54	433	2,662	27	3,647	1.35	4,923
1995	12,000	61	7,320	95	294	59	448	3,279	25	4,372	1.35	5,903
2000	12,600	65	8,190	103	296	65	464	3,800	23	4,935	1.35	6,663
2005	13,100	68	8,908	112	298	70	480	4,276	21	5,412	1.35	7,307
2010	13,600	70	9,520	120	300	74	494	4,703	20	5,879	1.35	7,936

SAN KAMPHAENG SANITARY DISTRICT

YEAR	POP.	SER. RATIO (%)	SERVED POP.	PER-CAPITA DEMAND (lpcd)	OTHERS DEMAND (lpcd)	T O T A L DEMAND (lpcd)	(m3/day)	UN-ACCOUNT RATIO (%)	AVE-DAY DEMAND (m3/day)	PEAK FACTOR (1)	MAX-DAY DEMAND (m3/day
1985	17,000	34	5,780	80	50	130	751	33	1,121	1.35	1,514
1990	18,800	43	8,084	87	54	141	1,140	27	1,561	1.35	2,108
1995	20,600	50	10,300	95	59	154	1,586	25	2,115	1.35	2,855
2000	22,400	57	12,768	103	65	168	2,145	23	2,786	1.35	3,761
2005	24,200	62	15,004	112	70	182	2,731	21	3,457	1.35	4,666
2010	26,100	65	16,965	120	74	194	3,291	20	4,114	1.35	5,554

SAN SAI SANITARY DISTRICT

YEAR	POP.	SER. RATIO (%)	SERVED POP.	PER-CAPITA DEMAND (lpcd)	OTHERS DEMAND (lpcd)	T O T A L DEMAND (lpcd)	(m3/day)	UN-ACCOUNT RATIO (%)	AVE-DAY DEMAND (m3/day)	PEAK FACTOR (1)	MAX-DAY DEMAND (m3/day
1985	22,200										
1990	22,700										
1995	23,200										
2000	23,700	36	8,532	98	60	158	1,348	23	1,751	1.35	2,363
2005	24,200	44	10,648	105	65	170	1,810	21	2,291	1.35	3,093
2010	24,700	50	12,350	120	72	192	2,371	20	2,964	1.35	4,001

Table-6.12 SUMMARY OF POPULATION AND WATER DEMAND

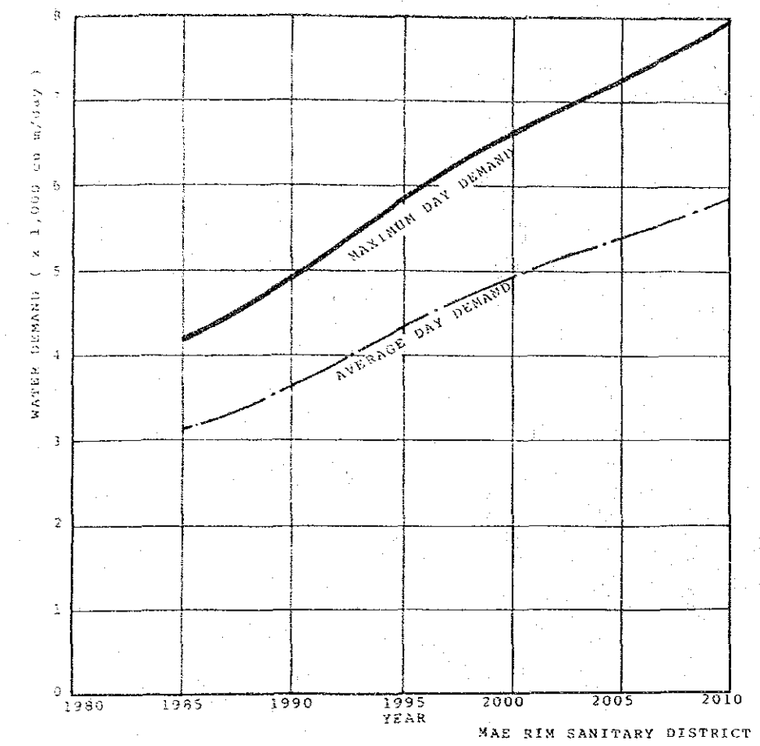
(Continued)

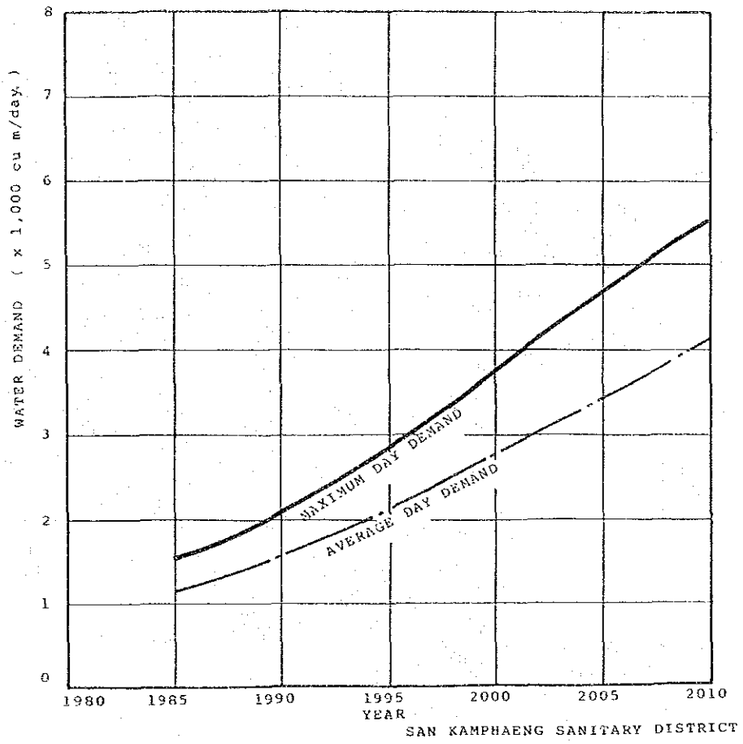
SARAPHI SANITARY DISTRICT

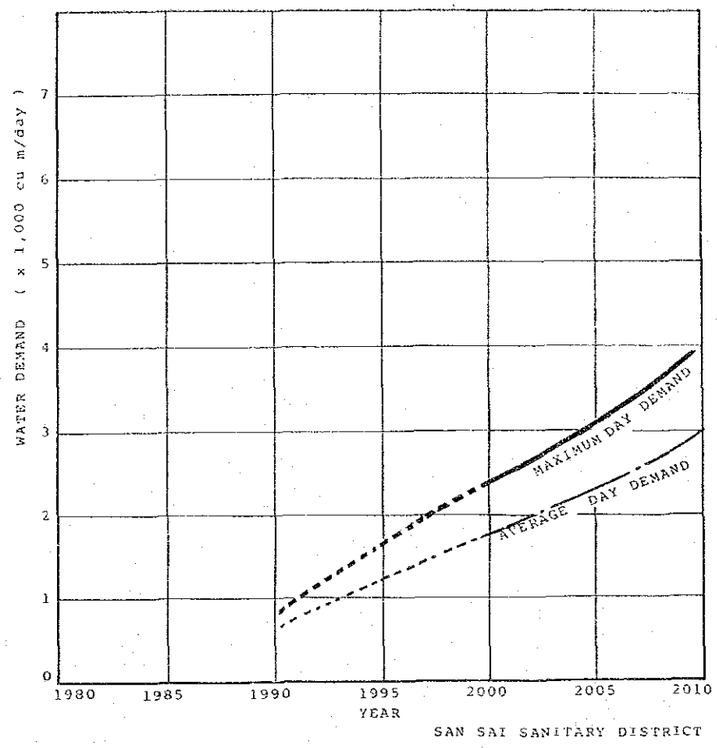
YEAR	POP.	SER. RATIO (%)	SERVED POP.	PER-CAPITA DEMAND (lpcd)	OTHERS DEMAND (lpcd)	T O T A L DEMAND (lpcd)	(m3/day)	UN-ACCOUNT RATIO (%)	AVE-DAY DEMAND (m3/day)	PEAK FACTOR (1)	MAX-DAY DEMAND (m3/day
1985	8,800										
1990	9,600										
1995	10,300										
2000	11,100	36	3,996	98	60	158	631	23	820	1.35	1,107
2005	12,000	44	5,280	105	65	170	898	21	1,136	1.35	1,534
2010	13,000	50	6,500	120	72	192	1,248	20	1,560	1.35	2,106

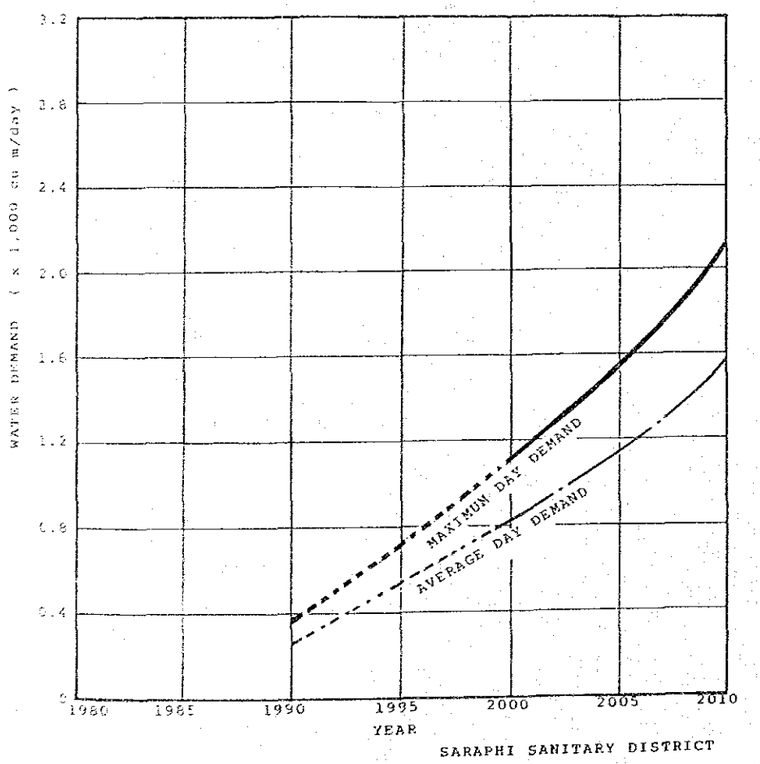
HANG DONG SANITARY DISTRICT

YEAR	POP.	SER. RATIO (%)	SERVED POP.	PER-CAPITA DEMAND (lpcd)	OTHERS DEMAND (lpcd)	T O T A L DEMAND (lpcd)	(m3/day)	UN-ACCOUNT RATIO (%)	AVE-DAY DEMAND (m3/day)	PEAK FACTOR (1)	MAX-DAY DEMAND (m3/day
1985	5,200	0	0	0	0	0	0	0	0	1.35	0
1990	5,500	15	825	80	50	130	107	27	147	1.35	198
1995	5,800	27	1,566	89	55	144	226	25	301	1.35	406
2000	6,100	36	2,196	98	60	158	347	23	451	1.35	608
2005	6,400	44	2,816	105	65	170	479	21	606	1.35	818
2010	6,700	50	3,350	120	72	192	643	20	804	1.35	1,085









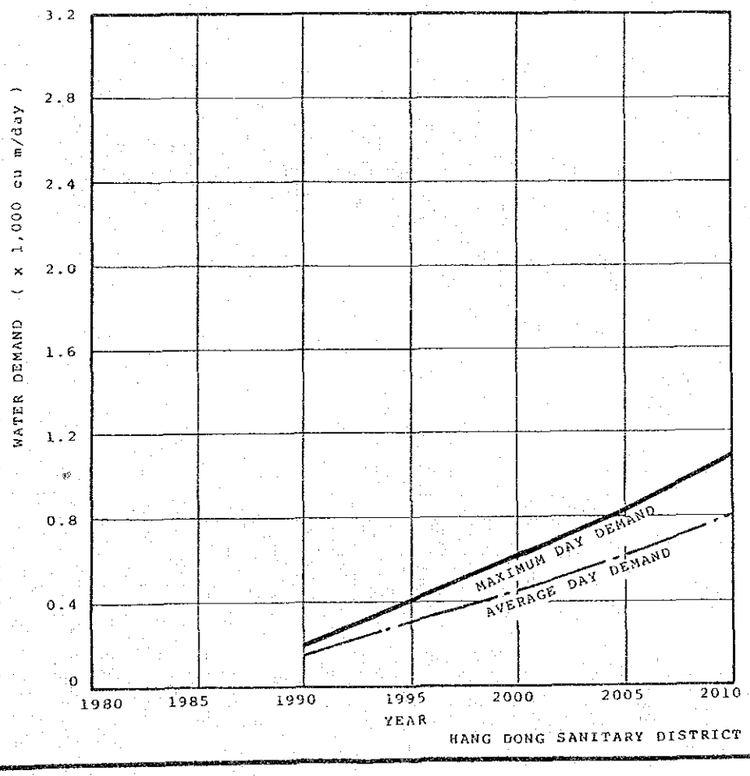


FIGURE 6.3	FUTURE AVERAGE DAY AND MAXIMUM DAY WATER DEMAND OF 5 SANITARY DISTRICTS
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CHAPTER 7 PROPOSED WATER SUPPLY SYSTEM

CHAPTER 7 PROPOSED WATER SUPPLY SYSTEM

In the previous Chapters all basic factors to govern the planning of the long-term development plan of the water supply systems have been studied, including the prevailing conditions of the supply area, the existing water supply conditions, the trends of population growth and water requirements. Taking all the founding and results of the studies into account, the development plan will be worked out hereinafter, which is most appropriate, technically and economically, for the study area.

7.1 Basic Considerations for Development Plan

Formulation of the long-term development plan of Chiangmai and Five Sanitary Districts Water Supply Project will be based on the following basic considerations:

1) Earliest Possible Realization of Water Supply

Emphasis will be placed on earliest possible realization of water supply to the areas where supply is insufficient or supply is urgently required by means of rehabilitation and modification of existing facilities.

a) Deteriorated equipment in the treatment plants and obsolete pipelines as described in Chapter 5 will be rehabilitated, and problems concerning operation and maintenance will be so solved as to enable supplying safe water continuously.

b) To reduce leakage from the water main, leak detectors will be provided and a leakage control program will be prepared.

c) Inexpensive and effective improvement works for uprating production will be carried out.

2) Phased Implementation of Project

To achieve cost-effective implementation of the whole project, the service area will be expanded, or the pipelines will be extended

according to the urgency of supply in individual areas.

a) In accordance with the future plans of Regional Office and Waterworks and in consideration of the development of the service area and water demand, the development plan of the study area will be phased into two stages, i.e., Stage I up to 2000 and Stage II up to 2010.

b) San Sai and Saraphi have not water supply systems, and the residents are using groundwater. Hang Dong has its water supply system taking groundwater. As public water supply in these three sanitary districts are considered not so urgent compared with other districts, it is recommendable to take up these three districts in Stage II.

c) The service area of Mae Rim is already connected with that of Chiangmai. Along the main road connecting San Kamphaeng and Chiangmai, there are many factories and shops, and so the area along this road is planned as the service area. From the above condition, it is considered most appropriate to run the water supply for Mae Rim, Chiangmai and San Kamphaeng under a composite waterworks, and the present development plan is prepared accordingly.

3) Most Appropriate Technology

Strictly in compliance with the design criteria established by PWA, least cost designs will be employed, rather placing emphasis on labor intensive technology.

a) In planning and designing the present water supply system, the plan of PWA now under way or under construction will be studied as reference.

b) Construction methods, and mechanical/electrical equipment, currently employed widely in Thailand, will be used as much as practicable. Emphasis will be placed on easy and mistake-free operation and maintenance.

Succeeding sections first describe proposed water sources for the long-term development plan. Then, rehabilitation and modification of existing facilities to be executed under Stage I are outlined. Finally, it describes Stage I and Stage II Expansion Works for future water supply system in Chiangmai and five sanitary districts. Water supply Plan worked out in accordance with the above description is presented in Fig-7.1.

7.2 Water Source and Water Supply System

7.2.1 Water Source

Future water sources for Chiangmai and five sanitary districts are discussed in detail in Appendix 3 STUDY ON WATER SOURCES. Based on the results of the study, the future water sources are concluded as stated below.

1) Chiangmai

The Ping River and Mae Taeng Irrigation Canal used presently for the supply will be able to manage the water demand in 2000, the target year of the Stage I.

To meet the demand amounting 97,900 cu m/d or 28.6 MCM/year in 2010, the target year of the Stage II, the Mae Kuang River and groundwater in the area are found to be available in this study, as additional sources to the mentioned.

The Mae Kuang River, because of the abundance of flow, will guarantee stable supply, but the investment costs of treatment and transmission and the running costs related to the source's use are found to be rather high.

The groundwater development, because of lower operation cost than in the case of treating surface water, is attractive. However, regarding the investment cost, it is obviously high as many wells of limited production capacity and sizable length of pipelines to connect the wells are needed.

The Mae Ngat Dam, located about 40 km upstream of Chiangmai city, was

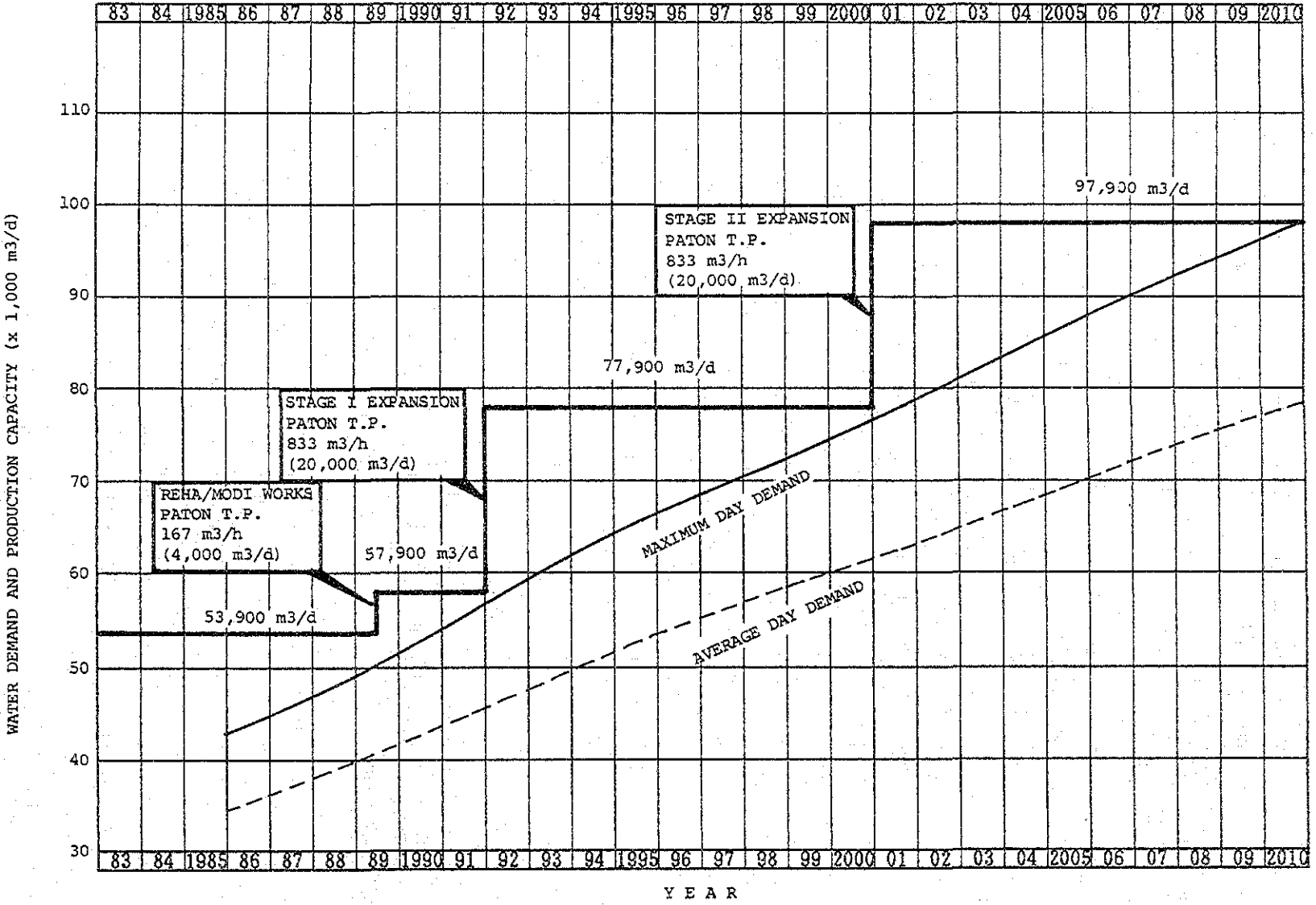

FIGURE	WATER SUPPLY PLAN TO YEAR 2010
7.1.(1)	(CHIANGMAI)
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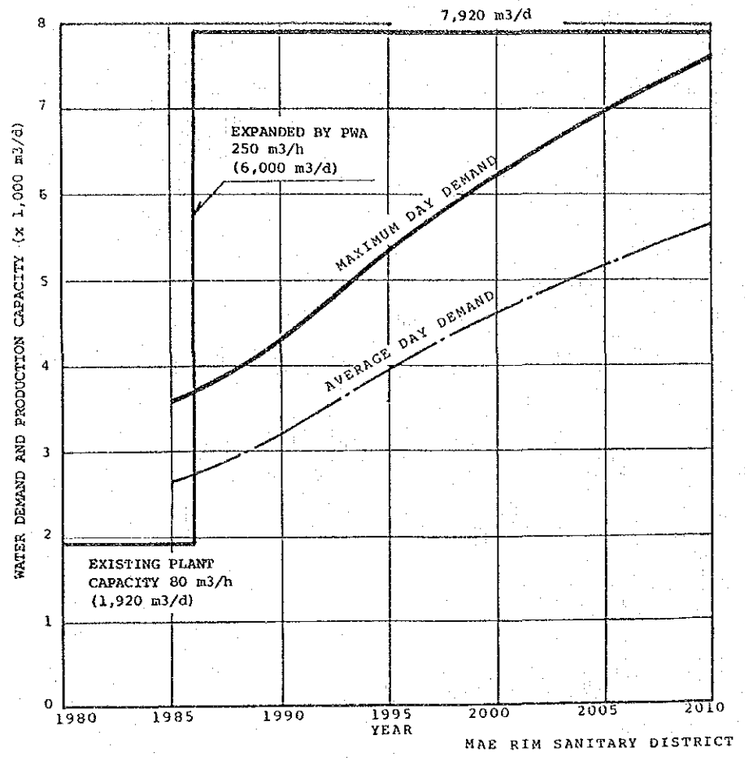

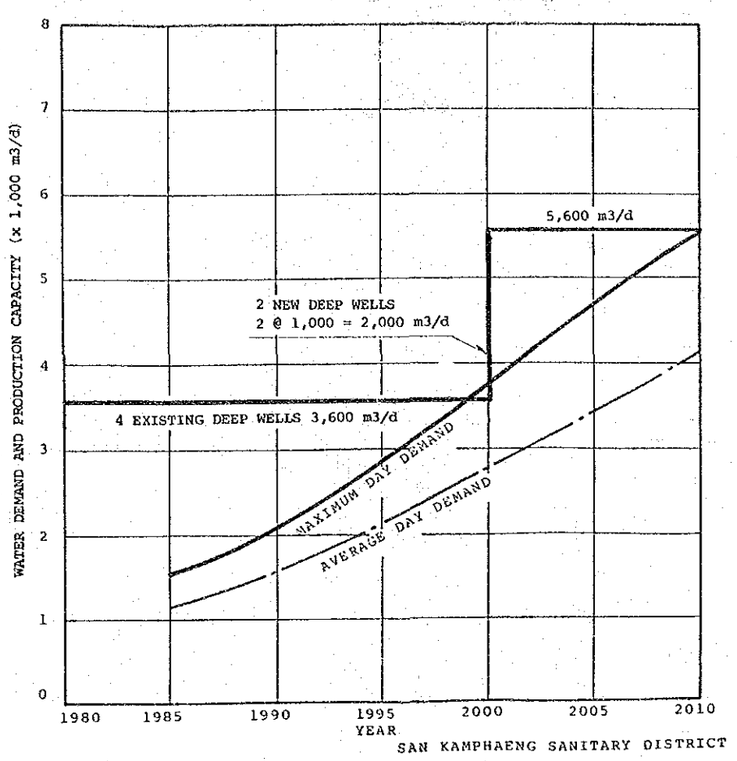

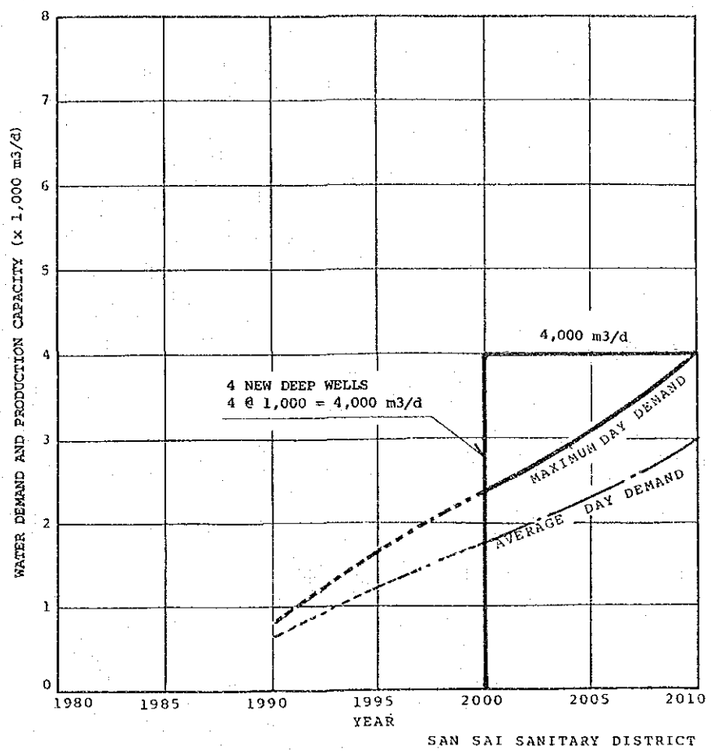

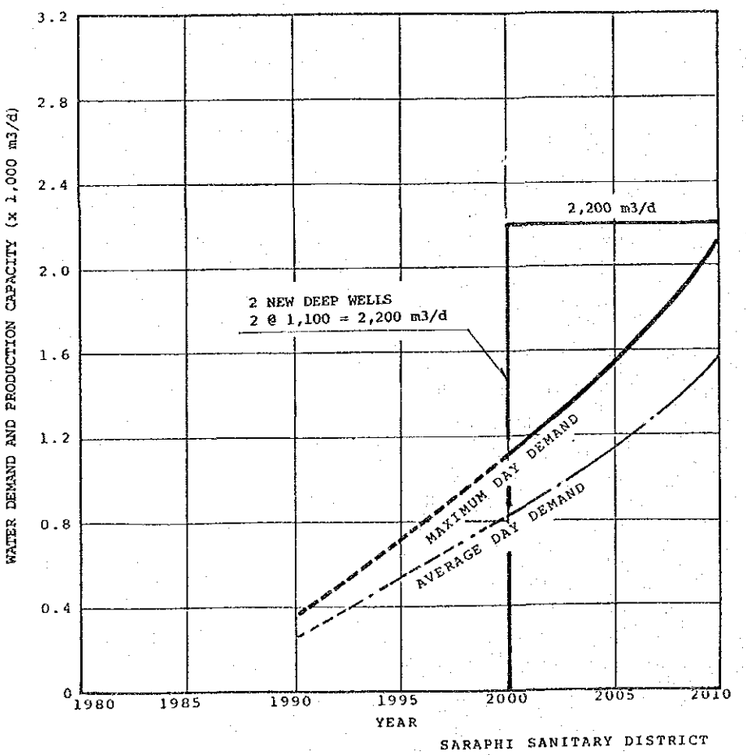

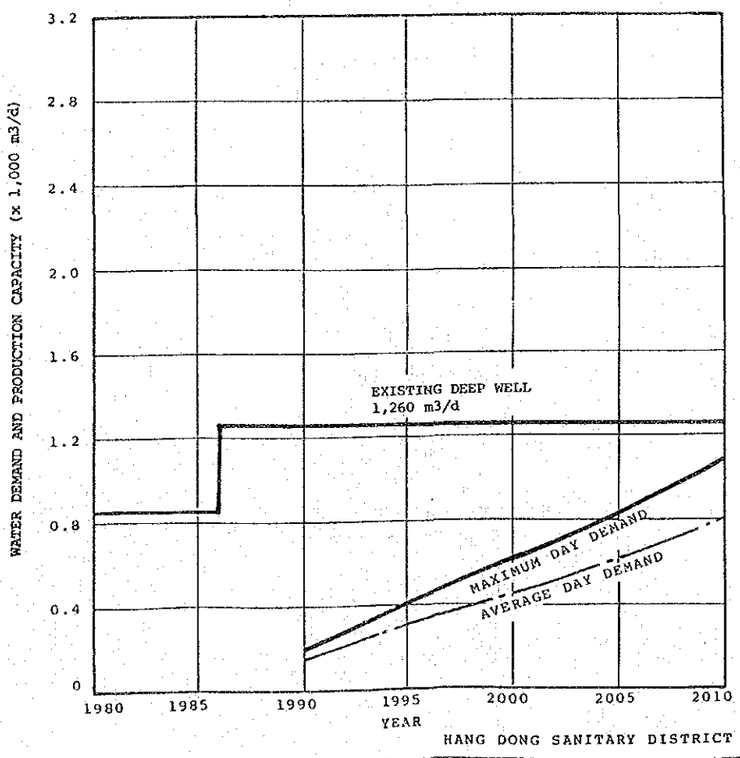

FIGURE	WATER SUPPLY PLAN TO YEAR 2010
7.1.(2)	(5 SANITARY DISTRICTS)

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completed in 1986 to dam up the mainstream of the Ping River and store 265 MCM. The impounded water is used for hydropower generation at the damsite and afterwards, when discharged to the river, for irrigation and the Chiangmai's water supply. The planned control of dam operation by RID will be effective in stabilizing the flow of the river.

Considering the stabilized flow and the availability of land space in the Paton Treatment Plant site for expanding facilities, the most preferable water source for the State II will be the Ping River.

Although the river turbidity generally increases in the rainy season and iron content is comparatively high throughout the year, the quality of the river water is acceptable as the future water source.

2) 5 Sanitary Districts

a) Mae Rim

The Lam Nam Mae Sa rivulet is the future water source for the Mae Rim Waterworks. The rivulet discharges a part of the flow to the raw water reservoir, expanded in 1986 to the present capacity of 50,000 cu m.

As judged by the field survey, the stream flow seems to be sufficient to cover the treatment capacity, but installation of an observation station and periodical measurement by PWA at an earlier date are recommended, because information of the river flow is of essential necessity.

The raw water quality is acceptable for the treatment process, as justified by the fact that the treated water quality satisfies the PWA drinking water standards. Degradation of quality in the foreseeable future is not probable.

b) San Kamphaeng

Groundwater potential is high in San Kamphaeng Sanitary District, and the groundwater productivity ranges from 1,000 to 3,000 cu m/day/well of the depth of aquifers, ranging from 100 to 160 m. Existing 4 deepwells used for the public water supply are producing a total of 3,600 cu m/day which

will be able to cover the demand in 2000. To meet the increased demand in 2010, however, drilling of 2 wells, each capacitated for 1,000 cu m/d production, are planned. The space of two wells to be located in the district shall be about 1.0 km at least, to prevent mutual interference.

The groundwater generally contains some iron and manganese. Therefore, it is necessary to consider treatment by aeration and/or pre-chlorination followed by filtration.

c) San Sai

Groundwater is abundant in San Sai area and will be used as the future water source. The groundwater potential is expected to be about 1,000 cu m/day/well, and therefore, 4 deepwells producing a total of 4,000 cu m/day will be able to cover the water demand for the year 2010.

The groundwater generally has a high content of iron in this area and treatment by aeration and/or pre-chlorination followed by filtration is to be considered, depending on the conditions.

d) Saraphi and Hang Dong

These two Sanitary Districts are located in the Ping river artesian groundwater basin where groundwater potential is very high. Groundwater is recommendable as the water source for these waterworks. The groundwater productivity is expected to range from 1,000 to 3,000 cu m/day/well with aquifer's depth ranging from 100 to 160 m.

The groundwater generally contains some iron and manganese in this area. Therefore, treatment by aeration and/or pre-chlorination followed by filtration is to be considered, depending on the conditions.

The Hang Dong S.D. waterworks has 2 existing deepwells with a total capacity of 1,260 cu m/day which can cover the demand up to 2010. Saraphi S.D. will have to construct a new waterworks in the service area including 2 deepwells with capacity of 1,100 cu m/day/well, to supply the demand in 2010.

7.2.2 Water Supply System

Selection of the proposed treatment plant site together with transmission route is a key factor to establish a long-term development plan up to the year 2010.

1) Chiangmai

In the foregoing Section 7.2.1, the Ping River and the Mae Tang Irrigation Canal are proposed as the future water sources up to 2010. At present, the three treatment plants of Wang Sing Kam, Umong and Paton supply water to the consumers in Chiangmai Municipality.

Of the three treatment plants, the Paton plant site is wide enough for the planned future expansion of facilities. The expansion works will be made on the Ban Tho Intake, raw water transmission pipeline and the Paton plant which form the present Paton system.

2) Mae Rim

The Lam Nam Me Sa will be the future water source of the Stage I and II projects, as it is the present source. The raw water is pumped to the Mae Rim Treatment Plant, treated and distributed by gravity. The existing treatment capacity will be able to cover the 2010 demand, but the raw water transmission and distribution pipelines will have to be reinforced to accord with increased requirement.

3) San Kamphaeng

In the Stage I, capacity of the existing deep wells and facilities in the San Kamphaeng Treatment Plant will cover the 2000 demands.

As for the Stage II, new deep wells will have to be developed at the eastern part of the district and in case excessive iron and manganese are found in the water, a treatment equipment will have to be provided.

4) San Sai, Saraphi and Hang Dong

Deep wells will be newly developed to meet the 2010 demands for San Sai and Saraphi Sanitary Districts. For Hang Dong District, the existing deep wells have enough capacity to cover the 2010 demands. Facilities for iron and manganese removal will be constructed for 3 Sanitary Districts, if necessary.

The long-term development plan for Chiangmai and five sanitary districts is shown on Fig-7.2. In the succeeding sub-sections, further detailed technical particulars on each works are described.

7.3 Stage I Rehabilitation and Modification Works

The rehabilitation/modification works are mainly focused upon the Paton Treatment Plant to increase the supply capacity, while replacement of deteriorated pipelines to reduce the unaccounted-for water is also included.

The items recommended for the rehabilitation/modification are summarized below:

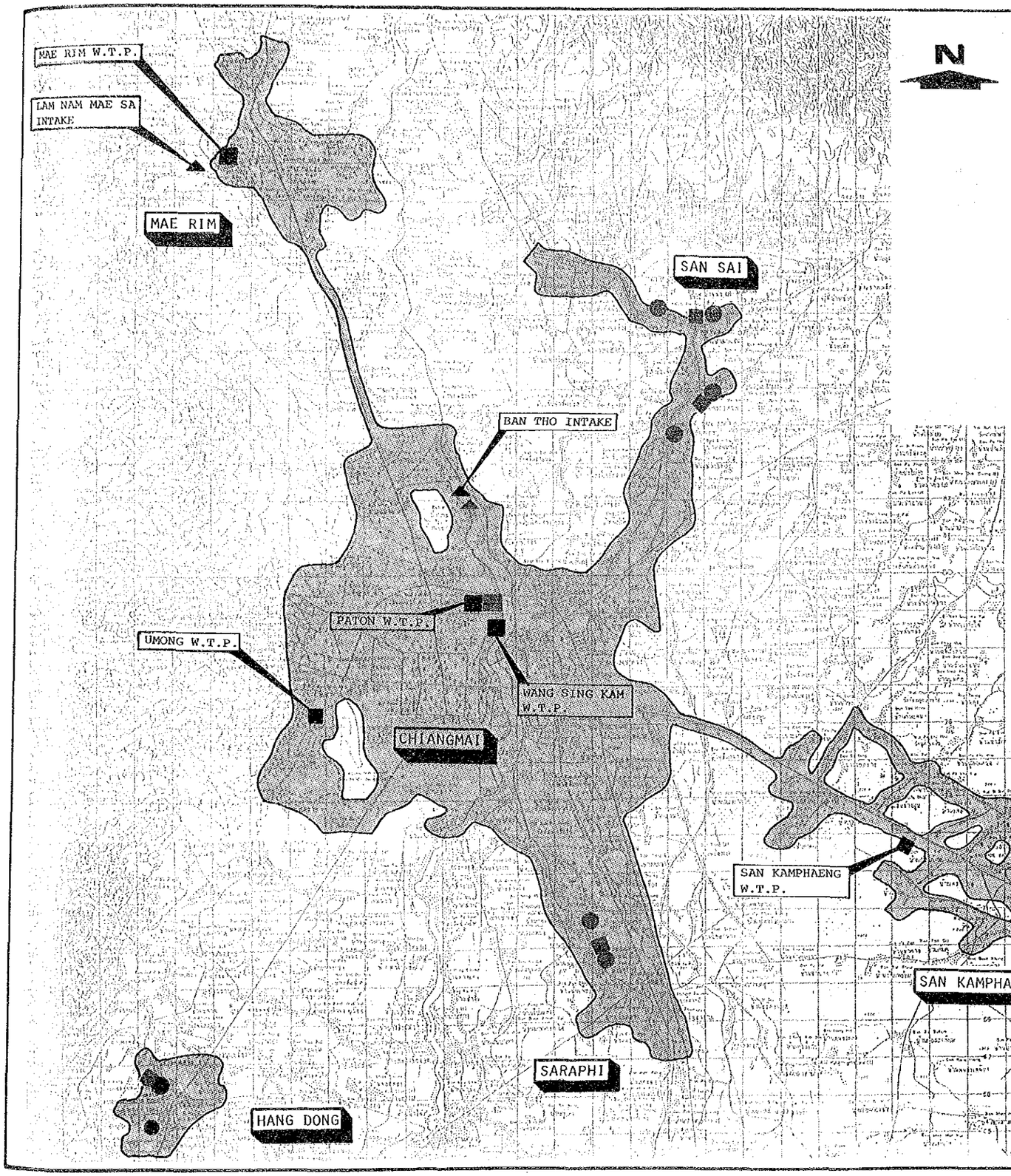
7.3.1 Chiangmai

(1) Install additional two raw water pumps at the Ban Tho Intake;

(2) Replace or Install alum and lime feeding equipments of the three treatment plants;

(3) Replace water meters and indicators for the raw water of the three plants and treated water of the Wang Sing Kam and Paton plants;

(4) Replace level gauges of the clear water reservoir of the three plants;



ITEM	STAGE I YEAR 2000	STAGE II YEAR 2010
1) CHIANGMAI		
- INTAKE BARRAGE, GRID CHAMBER AND PUMP STATION	1 LS	-
- RAW WATER TRANSMISSION PIPELINE (BY PUMPING)	ø 500, L = 3.1 km	ø 500, L = 3.1 km
- NEW TREATMENT PLANT	20,000 m3/d	20,000 m3/d
- DISTRIBUTION PIPELINES	ø 100 to ø 500, L = 105 km	ø 100 to ø 300, L = 85 km
2) MAE RIM		
- RAW WATER TRANSMISSION PIPELINE (BY PUMPING)	ø 300, L = 0.9 km	-
- DISTRIBUTION PIPELINES	ø 100 to ø 250, L = 21 km	ø 100 to ø 200, L = 12 km
3) SAN KAMPHAENG		
- DEEP WELL AND TREATMENT PLANT	-	2,000 m3/d
- DISTRIBUTION PIPELINES	ø 100 to ø 200, L = 9 km	ø 100 to ø 200, L = 7 km
4) SAN SAI		
- DEEP WELL AND TREATMENT PLANT	-	4,000 m3/d
- DISTRIBUTION PIPELINES	-	ø 100 to ø 200, L = 26 km
5) SARAPHI		
- DEEP WELL AND TREATMENT PLANT	-	2,200 m3/d
- DISTRIBUTION PIPELINES	-	ø 100 to ø 200, L = 23 km
6) HANG DONG		
- TREATMENT PLANT	-	1,260 m3/d
- DISTRIBUTION PIPELINES	-	ø 100 to ø 150, L = 11 km

LEGEND

- : EXISTING TREATMENT PLANT
- : PROPOSED TREATMENT PLANT
- : EXISTING DEEP WELL
- : PROPOSED DEEP WELL
- : EXISTING INTAKE FACILITY
- : PROPOSED INTAKE FACILITY
- : SERVICE AREA IN 2010

W.T.P.: WATER TREATMENT PLANT

0 2 4 6 km

FIGURE 7.2 LONG TERM DEVELOPMENT PLAN

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(5) Provide a chlorine gas container scale for the three plants;

(6) Replace filter media and underdrain of the filter of the three plants, or thoroughly clean filter media;

(7) Replace broken sludge collecting pipes of the 1,000 cu m/h sedimentation basin of Umong;

(8) Provide a simple device to accelerate floc settlement under the planned, increased flow rate of Paton;

(9) Replace unrepairable distribution pump of Wang Sing Kam;

(10) Replace deteriorated pipelines of the distribution system;

(11) Purchase leakage detecting equipment, initiate a leakage control program and immediately replace defective mains if any;

(12) Purchase a filter sand washer and undertake regular wash of filter media.

If the works are successfully completed, the water demands up to 1991 will be managed by the present system in Chiangmai.

7.3.2 Mae Rim and San Kamphaeng

(1) Provide a chlorine gas container scale for each of the two plants

7.4 Stage I Expansion Works

7.4.1 Chiangmai

The Stage I Expansion Works make provisions for the maximum water demand of 76,600 cu m/d, served population of 127,000 and service area of 4,900 ha, all projected for the target year 2000.

Features of the proposed Works are as follows:

1) Intake and Raw Water Transmission Pipeline

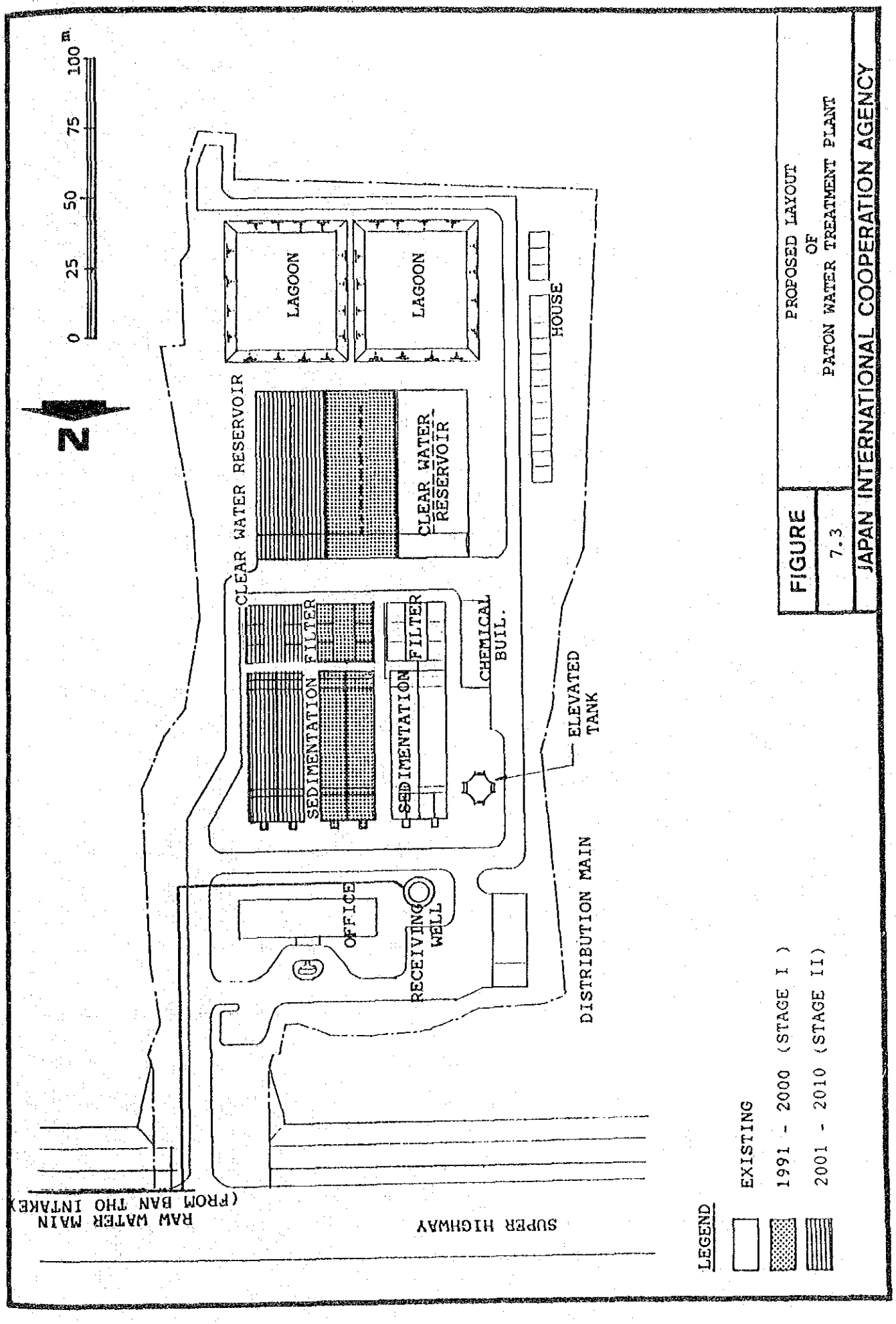
An intake barrage, maintaining a sufficiently high water level for taking in the rated flow of the Stage I and II, will be constructed at a down-stream point close to the proposed intake, as stated in Appendix 8, Section 8.2.2. A grit chamber and raw water pump station will be constructed adjacent to the existing Ban Tho Intake. Raw water will be taken by pumping and conveyed through a 500 mm main of 3,100 m length to the Paton plant.

2) Treatment Plant

The proposed treatment plant of 20,000 cu m/d capacity is located in the Paton Treatment Plant site, as there is a space wide enough for laying out two more plants of same size as the existing 20,000 cu m/d facility. The water treatment process will consist of pre-liming, coagulation, floc-culation, sedimentation, filtration and post-chlorination. Some parts of the existing facilities, such as receiving well, sludge lagoon and distri-bution pump station, will be used without change, in the expansion plan. Layout of the proposed plants is shown on Fig-7.3.

3) Distribution and Service

New distribution pipelines with a total length of 105 km are planned for delivering the water demand in 2000.


0 25 50 75 100 m
N
LAGOON
LAGOON
HOUSE
CLEAR WATER RESERVOIR
CLEAR WATER RESERVOIR
SEDIMENTATION
FILTER
SEDIMENTATION
FILTER
CHEMICAL BUIL.
ELEVATED TANK
OFFICE
RECEIVING WELL
DISTRIBUTION MAIN
SUPER HIGHWAY
RAW WATER MAIN (FROM BAN THO INTAKE)
LEGEND
EXISTING
1991 - 2000 (STAGE I)
2001 - 2010 (STAGE II)
FIGURE 7.3
PROPOSED LAYOUT OF PATON WATER TREATMENT PLANT
JAPAN INTERNATIONAL COOPERATION AGENCY

Installation of 4,900 additional service connections to meet about 26,000 incremental served population, is proposed in the Stage I.

7.4.2 Mae Rim

An additional raw water transmission pipe with dia. 300 mm of 900 m length is proposed. To serve 1,800 incremental population, distribution pipelines of 21 km length and 310 service connections will be installed.

7.4.3 San Kamphaeng

Installation of 9 km length distribution pipelines and 1,000 service connections are proposed to serve 4,200 incremental population.

7.5 Stage II Expansion Works

7.5.1 Chiangmai

The Stage II Expansion Works will provide additional 20,000 cu m/d production to meet the maximum water demand of 97,900 cu m/d by 2010.

1) Intake and Raw Water Transmission Pipeline

The existing and additional grit chamber constructed in Stage I will be used. New raw water pumps will be installed in the pump house constructed in Stage I.

A dia. 500 mm raw water transmission pipeline will be installed in addition to that laid in Stage I.

2) Treatment Plant

In Stage II, a 20,000 cu m/d treatment facility is planned to be constructed at the Paton plant site, by the Stage I facility's side. The Treatment process applied will be same as the Stage I's such as including flash

mixing, flocculation, sedimentation, filtration, electrical equipments and chemical feeding equipments.

3) Distribution and Service

The distribution system was analyzed to optimize the system up to the year 2010. As the result, the proposed system of the Stage II includes installation of 105 km long mains, ranging from 100 mm to 600 mm diameter. The Stage II Expansion Works propose installation of 4,700 additional service connections to serve 22,000 incremental population.

7.5.2 Mae Rim

About 12 km total length of distribution pipelines will be laid in the newly expanded service area under the Stage II and in the central area of the town where high consumption is anticipated.

7.5.3 San Kamphaeng

In the Stage II, facilities to meet the 2010 demand of 5,600 cu m/d shall be provided. Two 1,000 cu m/d capacity wells will be constructed to the east of the service area and, in case high iron content is detected, a system consisting of chlorine-contact chamber and filter will be provided.

Distribution pipelines, totaling about 7 km length, will be laid in the expanded service area and existing area which needs reinforcement.

7.5.4 San Sai, Saraphi and Hang Dong

San Sai will be provided with four wells, each producing 1,000 cu m/d, as the 2010 demand is estimated at 4,000 cu m/d.

Saraphi will see the construction of two wells to respond to the 2010 demand of 2,100 cu m/d.

The general layout plan of the wells is shown in Fig-7.4. The groundwater will contain iron very possibly and a treatment system of chlorine-contact chamber and filter will have to be provided.

Distribution pipelines are planned to cover the projected service area. Length of the pipelines will be, 1) 26 km for San Sai, 2) 23 km for Saraphi and 3) 11 km for Hang Dong. The estimated number of house connections and served population in the three sanitary districts in 2010 are:

Sanitary District	Number of House Connection	Number of Served Population
San Sai	2,200	12,400
Saraphi	1,200	6,500
Hang Dong	620	3,400

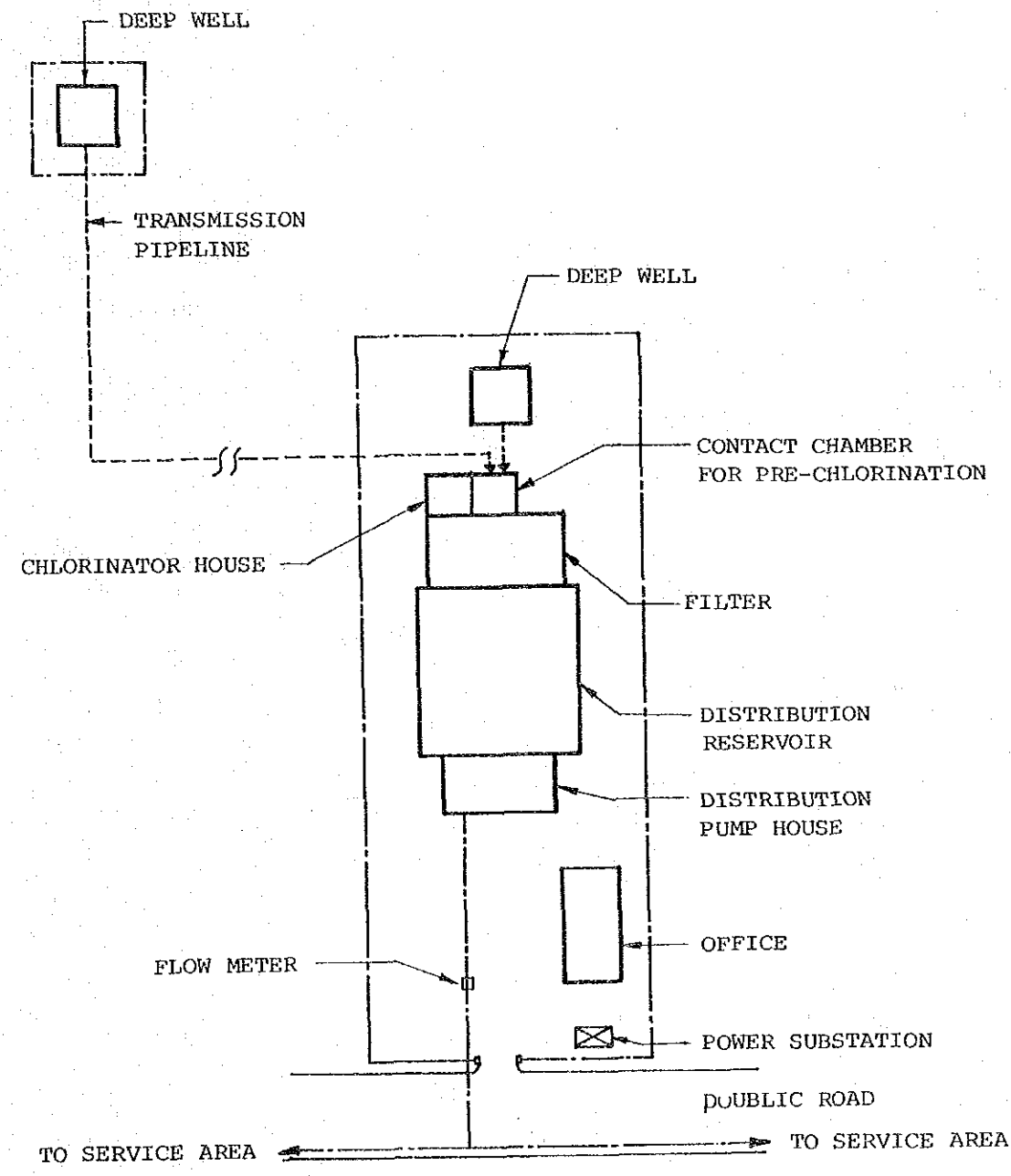


FIGURE	GENERAL LAYOUT OF DEEP WELLS FOR SANITARY DISTRICTS
7.4	

JAPAN INTERNATIONAL COOPERATION AGENCY

CHAPTER 8 PROJECT COST AND IMPLEMENTATION SCHEDULE

CHAPTER 8 PROJECT COST AND IMPLEMENTATION SCHEDULE

In this chapter, principal matters concerning the project cost and implementation schedule related to the water supply system, as proposed in Chapter 7, are described.

8.1 Price Level and References

Price level: Costs are valued at 1986 prices.

Unit cost : Those Unit costs in the PWA price lists are generally employed and where such price lists are not available, the prevailing market prices are referred to.

8.2 Division of Project Cost

The project cost is divided into two parts, as follows, to be estimated separately.

1) Construction costs; and
2) Other associated costs such as engineering and administrative costs, inclusive of physical and price contingencies.

8.3 Method of Estimation

The above mentioned costs are estimated in the following manner.

8.3.1 Construction Costs

The costs are estimates for each of the following three:

1) Stage I Rehabilitation and Modification Works
2) Stage I Expansion Works
3) Stage II Expansion Works

Construction costs shall include the cost of acquiring land necessary for the planned facilities. The land acquisition cost was estimated separately from the direct construction cost.

Summary of cost estimation is shown in Table-8.1(a) for Chiangmai, Mae Rim and San Kamphaeng, and Table-8.1(b) for San Sai, Saraphi and Hang Dong.

8.3.2 Associated Costs

The costs of engineering services, inclusive of detailed design, soil investigation and field survey, and supervision are estimated together with administrative cost, physical and price contingencies, as shown below. The coefficient used in the calculation is taken after the cased of on-going projects or the figures widely accepted in Thailand.

Where (A): Construction Cost, and

(B): Engineering Services Cost,

Detail Design (D/D) = (A) x 5.2 %
Soil Investigation and
Field Survey = (D/D) x 11 %
Supervision = (A) x 5.3 %

Administrative Cost (C) = (A + B) x 1 %

Physical Contingencies (D) = (A + B + C) x 7 %

Price Contingencies (E) = (A + B + C + D) x 3.3 % price escalation per annum for the construction period

Table-8.1(a) SUMMARY OF COST ESTIMATES
(CHIANGMAI, MAE RIM AND SAN KAMPHAENG)

(Unit : x 1,000 Baht)

Description	Stage I		Stage II
	Rehabilitation and Modification	Expansion	Expansion
1) Land Acquisition	-	1,800	1,000
2) Construction of New Water Supply System	22,400	200,600	183,400
3) Engineering Services	2,500	22,200	20,200
Sub total (A)=1)+2)+3)	24,900	224,600	204,600
4) Administration Cost (1% of Sub total (A))	200	2,300	2,000
Sub total (B)=(A)+4)	25,100	226,900	206,600
5) Physical Contingency (7% of Sub total (B))	1,800	15,800	14,500
Sub total (C)=(B)+5)	26,900	242,700	321,100
6) Price Contingency (3.3% per annum of total yearly disbursements)	3,100	36,800	168,600
Grand Total (C) + 6)	30,000	279,500	489,700

Table-8.1(b) SUMMARY OF COST ESTIMATES
(SAN SAI, SARAPHI AND HANG DONG)

(Unit : x 1,000 Baht)

Description	Stage II		
	San Sai	Saraphi	Hang Dong
1) Land Acquisition	2,000	1,000	-
2) Construction of New Water Supply System	42,700	24,800	5,100
3) Engineering Services	4,700	2,700	600
Sub total (A)=1)+2)+3)	49,400	28,500	5,700
4) Administration Cost (1% of Sub total (A))	500	300	100
Sub total (B)=(A)+4)	49,900	28,800	5,800
5) Physical Contingency (7% of Sub total (B))	3,500	2,000	400
Sub total (C)=(B)+5)	53,400	30,800	6,200
6) Price Contingency (3.3% per annum of total yearly disbursements)	30,700	17,700	3,600
Grand Total (C) + 6)	84,100	48,500	9,800

8.4 Implementation Schedule

8.4.1 Target Year

The development plan is phased into two stages, Stage I and II targeting 2000 and 2010 respectively, because of the following considerations:

- As many other cities waterworks under PWA management need similar development program also, dividing the period into more stages will be less appropriate administratively.

- Two stages' implementation will be appropriate from the viewpoint of size of investment.

- As other municipal plans for future set the target around 2000, the Stage I will be coordinated with them.

The Stage I is further phased into rehabilitation/modification of the existing system and expansion involving new construction works.

The areas of Stage I implementation are composed of Chiangmai and two surrounding Sanitary Districts, Mae Rim and San Kamphaeng as stated in the preceding Chapter 7. The scope of Stage II implementation covers San Sai, Saraphi and Hang Dong Sanitary Districts in addition to the Stage I implementation's.

8.4.2 Implementation Schedule of Stage I

In the Stage I, rehabilitation and modification works will be executed in advance of expansion works. The rehabilitation and modification works are planned for completion in the middle of 1989.

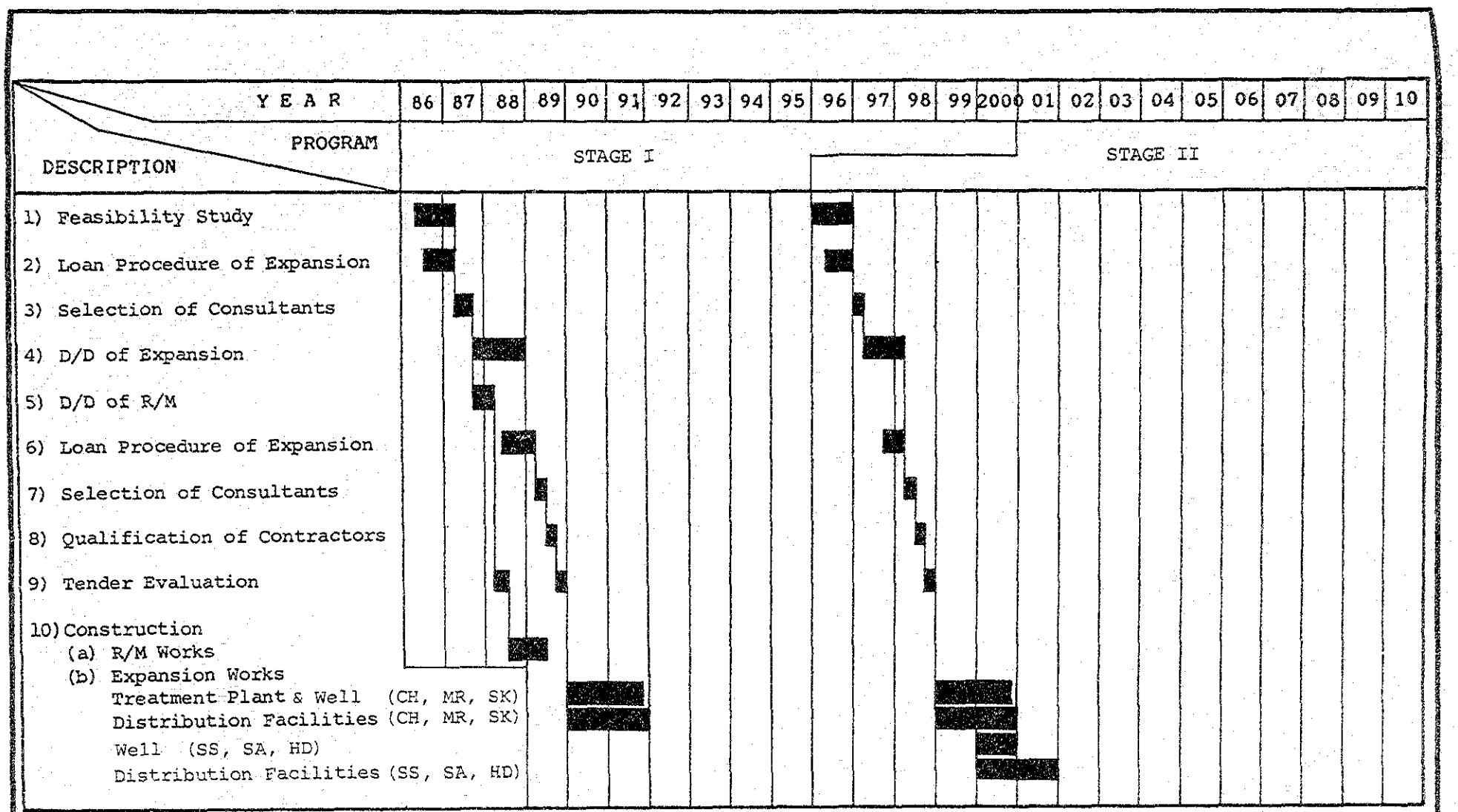
The expansion works and the rehabilitation and modification works are recommendable to be detail-designed coincidentally, as immediately after the completion of the rehabilitation and modification works the expansion works is to be commenced.

Two years' period is planned for the expansion works which involve a treat-

ment plant, distribution pump and reservoir station and a sizable length of pipeline. The whole works will have to be divided into a number of lots so that they can be progressed in parallel.

8.4.3 Implementation Schedule of Stage II

It is deemed necessary to complete the Stage II Project around the end of 2001, considering the water demand increase. Taking two years' period for the construction work as in the case of the Stage I Project, it will be required to commence the construction work at the beginning of 1999. Counting back from this time and allowing for a time period similar to the case of Stage I for feasibility study, loan procedure, etc., the commencement of feasibility study of Stage II is planned at the beginning of 1996, as detailed in Fig-8.1.



NOTE : D/D : Detailed Design
R/M : Rehabilitation and Modification

CH : Chiangmai
MR : Mae Rim
SK : San Kamphaeng
SS : San Sai
SA : Saraphi
HD : Hang Dong

FIGURE 8.1 IMPLEMENTATION SCHEDULE

JAPAN INTERNATIONAL COOPERATION AGENCY

CHAPTER 9 ORGANIZATION AND FINANCE

CHAPTER 9 ORGANIZATION AND FINANCE

9.1 Organization and Financial Status

9.1.1 Organization of PWA

PWA is a state enterprise with staff members totaling in 5,111 in February 1986 (Head Office - 841, Regional Offices - 592 and Waterworks - 3,678), supervised by the Board of Directors under the Ministry of Interior. The organization chart showing the lines of administration is illustrated in Fig-9.1.

For operating and maintaining 183 urban waterworks and providing technical guidance to 675 rural waterworks across the country, PWA owns 10 Regional Offices which directly supervise these urban waterworks and assist rural waterworks in technical aspects. The survey area waterworks in this report, Chiangmai, is supervise by Regional Office No. 9, which is organized as illustrated in Fig-9.2.

9.1.2. Organization of Regional Office

Regional Office No. 9, which is supervising Chiangmai, Mae Rim and San Kamphaeng Waterworks, is organized in the same manner as other regional offices and consist of the following 9 sections.

1) Personnel & clerical section, which is responsible of personnel administration of the waterworks under its control, including the training of waterworks personnel.

2) Finance & accounting section, which takes charge of finance and accounts of the water works under its control, inclusive of debiting and crediting of their bank accounts.

3) Procurement and stores section, which takes charge of procuring and storing materials and supplies necessary for operating water facilities of the waterworks under its control.

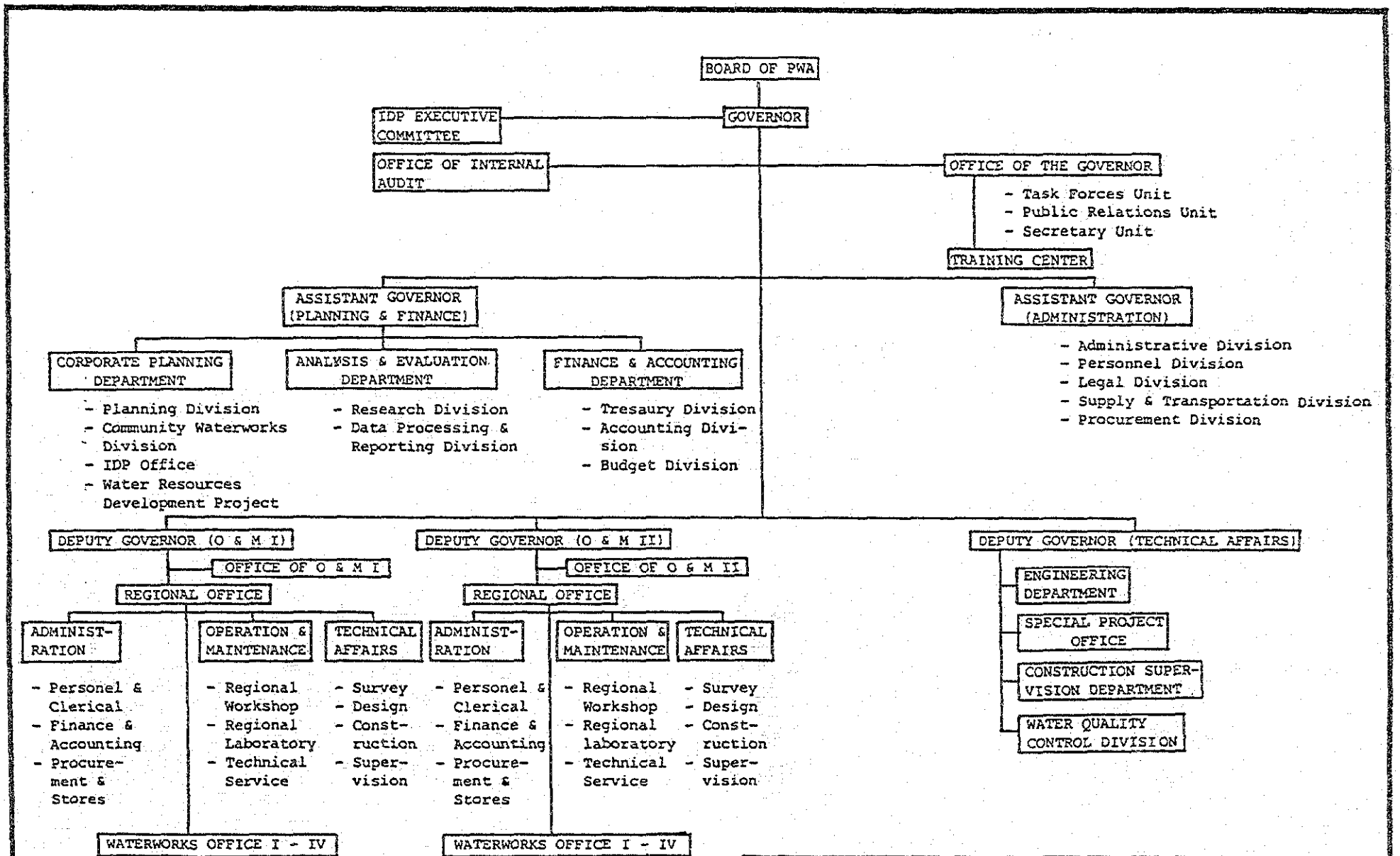
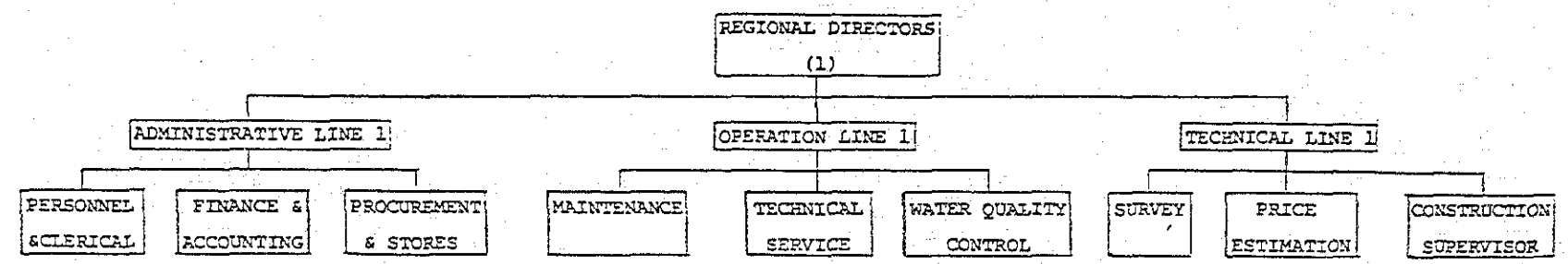


FIGURE 9.1 ORGANIZATION CHART OF PROVINCIAL WATERWORKS AUTHORITY

JAPAN INTERNATIONAL COOPERATION AGENCY



CHIEF	1	CHIEF	1	CHIEF	1	CHIEF	1	CHIEF	1	CHIEF	1	CHIEF	1	CHIEF	1	CHIEF	1	CHIEF	1
CLERK	4	FINANCE &		STORE -				MECHANIC	-	SCIENTIST	3	TEC-				TECHNICIAN	2	TECHNICIAN	3
TYPIST	1	ACCOUNT	6	KEEPER	3	ELECTRICIAN	2	TECHNICIAN	3			NICIAN	4						
DRIVER	5			LABOUR	1	MACHANIC	5	SKILL-											
JANITOR	1		7	CLERK	1	SKILL LABOUR	2	LABOUR	1		4		5		3		4		
SECURITY-					6		10		5										
STAFF	1																		
LABOUR	1																		
	14																		

PERSONNEL IN LINE	62
TECHNICIAN	4
MECHANIC	4
TOTAL	70

FIGURE	REGIONAL OFFICE IX CHIANGMAI (CONTROL 24 WATERWORKS)
9.2	

JAPAN INTERNATIONAL COOPERATION AGENCY

4) Maintenance section, which takes charge of giving guidance and instruction how to conduct operation and maintenance of the facilities of the waterworks under the control.

5) Technical service section, which provides preliminary survey of projected waterworks schemes for both urban and rural waterworks under its jurisdiction.

6) Water quality control section, which is responsible for conducting quality test of raw water under its control to test if the water meet the standards set by PWA.

7) Survey section, which is responsible for providing Head Office with information concerning rural waterworks and planning of new projects of water supply under its jurisdiction.

8) Price estimation section, which is responsible for estimating cost of expansion and rehabilitation of water supply systems both for urban and rural waterworks under its jurisdiction and preparing documents and drawings for tender bidding, etc.

9) Construction supervision section, which is responsible for supervising the construction and rehabilitation of water supply facilities mentioned in 8) above.

9.1.3 Organization of Waterworks

The proto-type organization of PWA waterworks, after which Chiangmai Waterworks is modeled, consist of the following 3 sections, as illustrated in Fig-9.3.

1) Water production section, which is responsible for operation and maintenance of water production facilities.

2) Service section, which provides services of setting and repairing house connections.

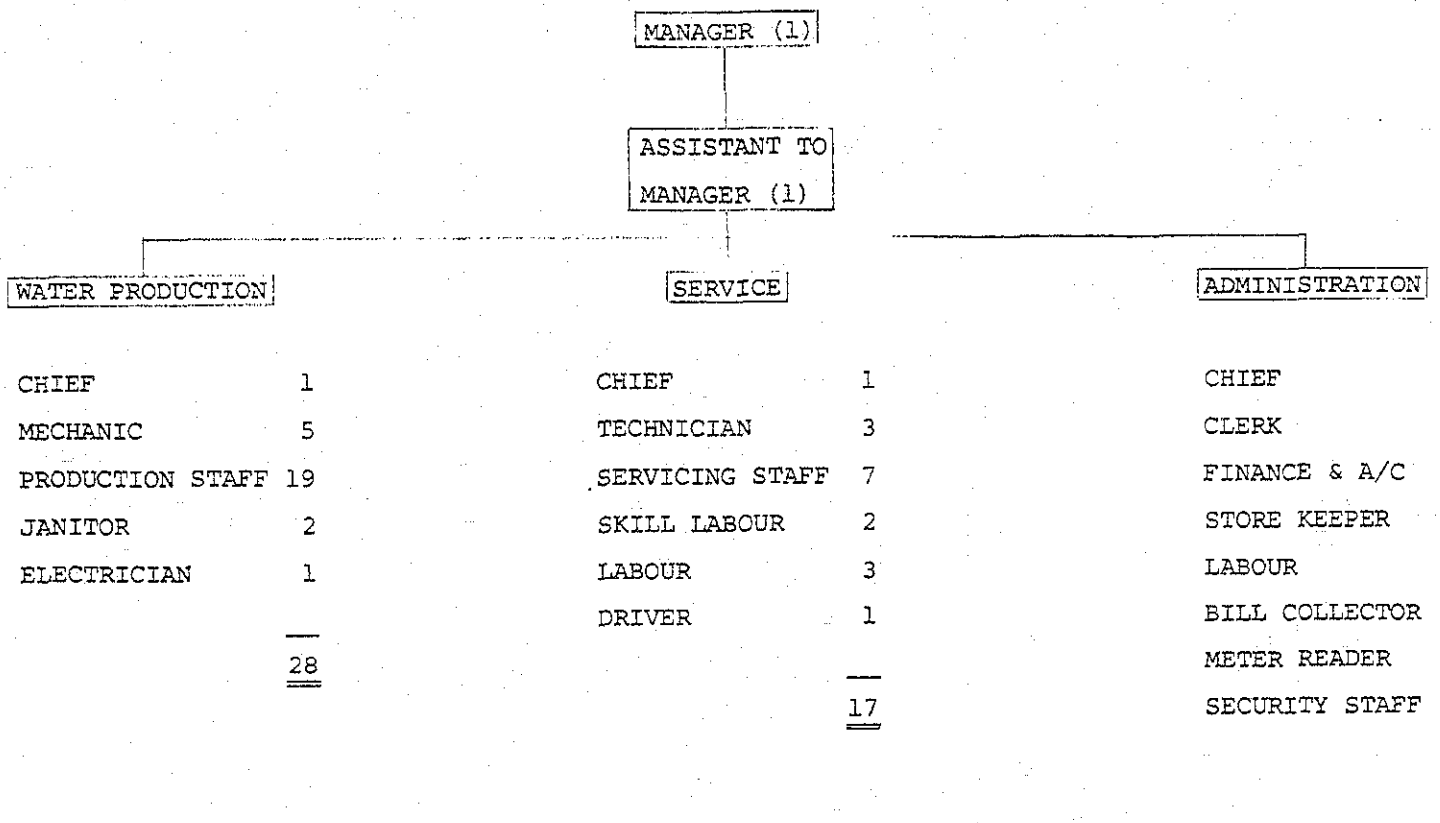


FIGURE 9.3 CHIANGMAI WATERWORKS

JAPAN INTERNATIONAL COOPERATION AGENCY

3) Administration section, which takes charge of meter-reading and bill-correction, book-keeping of customers accounts, financing, record-keeping of waterworks income and expenditure, and other administrative works and meters.

Due to their small size, Mae Rim and San Kamphaeng waterworks are composed only of two sections as illustrated in Figs-9.4 and 9.5.

9.1.4 Financial Status of PWA

It is the established for policy of the Thai government that the state enterprises including PWA should become self-financing, and thanks to continue effort to reduce operation expenses, the net income of PWA before depreciation and investment cost has turned to surplus since 1983 and that after depreciation turned to surplus in 1985. This means that PWA achieved the first of the five steps towards the self-financing target as shown in Figs-9.6 to 9.7 in 1983 and the 2nd in 1985.

PWA is making a effort to achieve better business, and revisions have been made in their accounting system. These revisions are of course welcome from long term view points, but these revisions break the continuity of financial records and are making analysis of time series difficult. Despite such inadequancy of study data, the financial statements shown in Tables-9.1 and 9.2 show that the operating ratio of PWA has greatly improved from 95.6 % in 1983 to 68.9 % in 1985 and demonstrated its effort to reduce operating cost.

PWA thus has come to the stage where revenue more than off-sets its operating expenses, but it still depends upon Government subsidies and financial assistance from abroad for capital investment which is indispensable for the Authority to perform its primary objective of serving water of adequate quantity and quality to the population of the entire country except the Bangkok Metropolitan Area. It is noted that almost half of the population are still using unsafe water.

MAE RIM WATERWORKS

MANAGER (1)

PRODUCTION		SERVICING & ADMINISTRATION	
CHIEF	1	CHIEF	1
PRODUCTION STAFF	3	SERVICING STAFF	1
		METER READER	1
	4	BILL COLLECTOR	1
		ACCOUNTING	1
		JANITOR	1
			5

TOTAL 10

SAN KAMPHAENG WATERWORKS

MANAGER (1)

PRODUCTION		SERVICING & ADMINAITRATION	
CHIEF	1	CHIEF	1
PRODUCTION STAFF	4	SERVICING STAFF	1
		ACCOUNTANT	1
	5	METER READER	1
		JANITOR	1
		SECURITY STAFF	1
			6

TOTAL 12

FIGURE 9.4

MAE RIM WATERWORKS AND SAN KAMPHAENG WATERWORKS

JAPAN INTERNATIONAL COOPERATION AGENCY

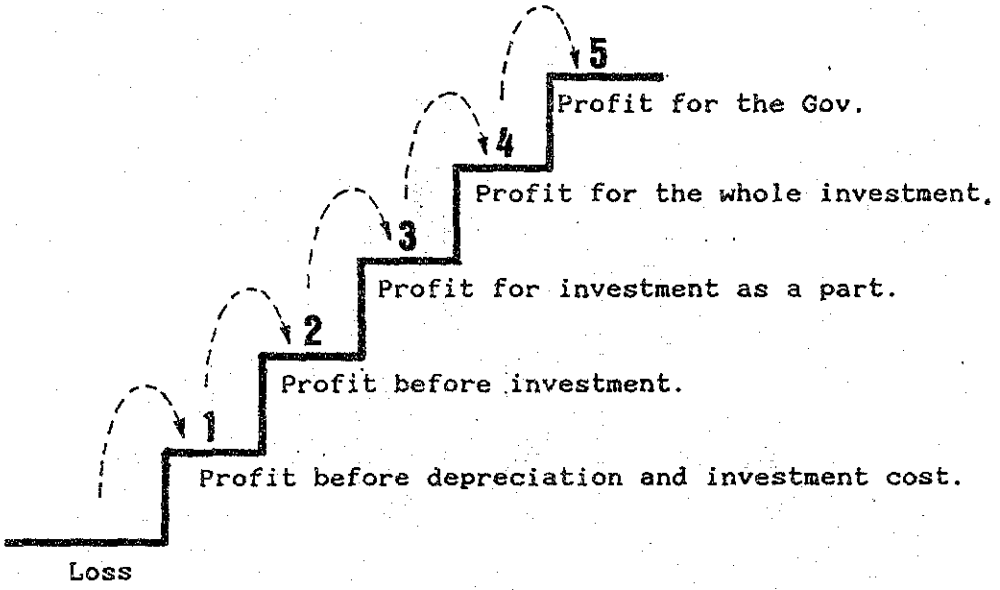


FIGURE	5 STEPS FOR ACHIEVEMENT OF SELF-FINANCING BY STATE ENTERPRISES
9.5	

JAPAN INTERNATIONAL COOPERATION AGENCY

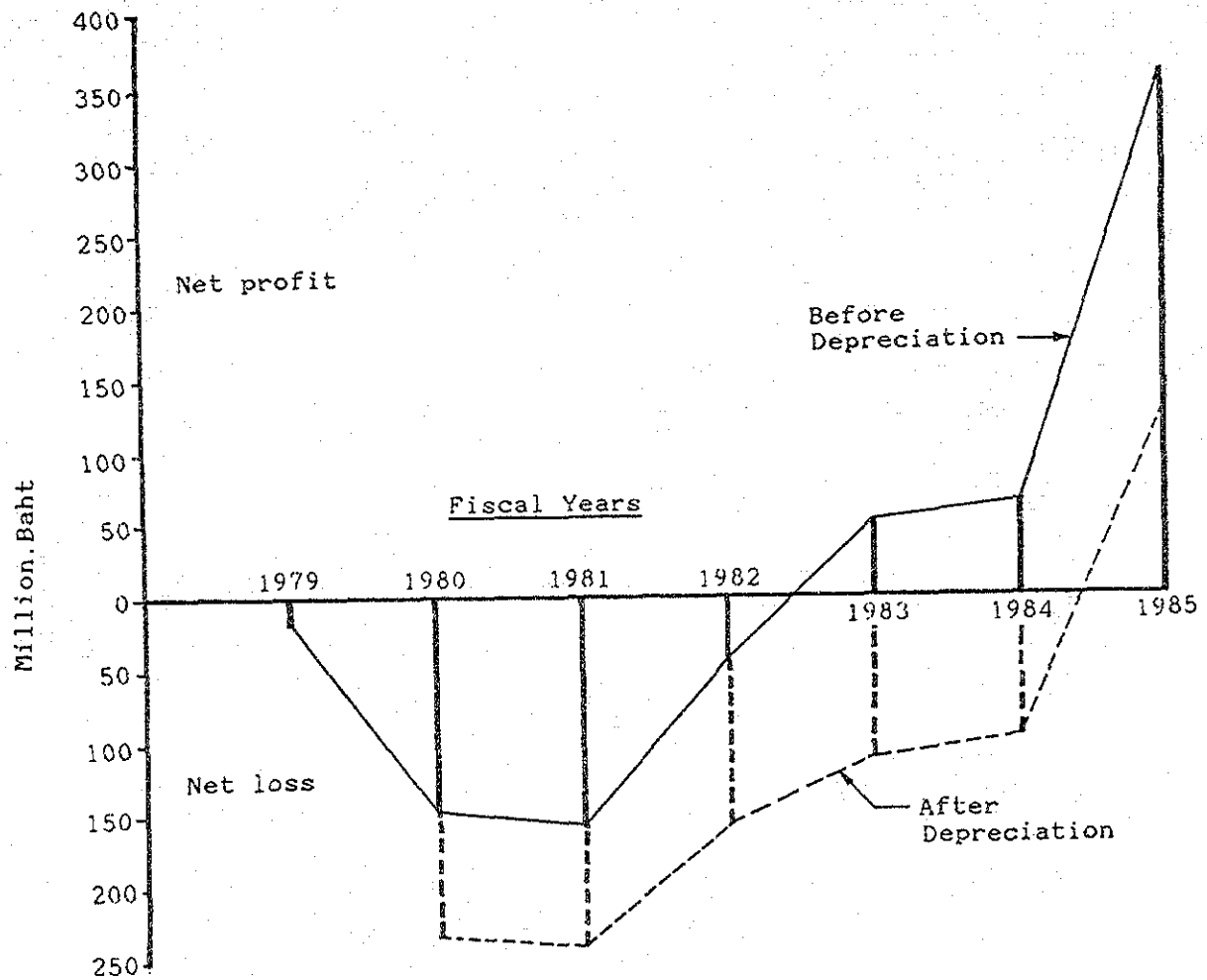


FIGURE	NET LOSS/PROFIT, FROM PWA OPERATIONS, 1979 TO 1985
9.6	

JAPAN INTERNATIONAL COOPERATION AGENCY

Table-9.1 PROVINCIAL WATERWORKS AUTHORITY
INCOME STATEMENT
1983 - 1986

Unit: Mil. Baht

	1983	1984	1985	1986 (Budget)
Revenue				
Water sales (net)	626.48	647.53	967.14	1,229.08
Service charge		52.74	54.50	57.15
Connection income	72.93	118.35	149.11	146.79
Other income	28.57	66.28	137.24	50.00
Total revenue	727.98	884.90	1,307.99	1,483.02
Operation expenses				
Salaries & Wages	304.74	325.81	351.12	384.44
Temporary wages	0.40	1.23	0.84	2.12
Remunerations	56.32	55.78	61.56	69.90
Chemicals	33.19	43.27	35.52	44.04
Material & Maintenance	48.21	35.27	39.67	66.28
Oil & fuel	22.36	15.69	14.50	18.41
Office supplies		9.84	6.65	10.64
Hire & service	2.31	12.55	52.08	54.35
Other operating expense	59.80	38.40	27.04	55.27
Public Utilities	2.23	18.23	6.77	21.71
Electricity	153.36	167.47	167.29	177.03
Interest & bank charge	13.03	22.99	66.57	104.56
Connection cost		46.27	71.56	85.68
Miscellaneous		0.37	0.56	20.00
Total expenses	695.95	793.17	901.73	1,114.43
Gross profit	32.03	91.73	406.26	368.59
Bad debt	0.01	0.72	0.09	1.00
Rural w/w expenses		1.49	1.03	1.50
Other expenses	13.68	-12.25	66.71	9.85
Profit (loss) before depriciation & amortization	18.34	101.77	338.43	356.24
Depriciation & amortization	136.32	149.14	174.58	200.44
Net profit (loss)	-117.98	-47.37	163.85	155.80

Note: 1. For 1983, material and maintenance includes office supplies.
2. Income statement is not approved by the auditor.

Table-9.2 Provincial Waterworks Authority
Balance Sheet
At the End of September 1983, 1984 and 1985

Unit: Mil. Baht

Assets	1983	1984	1985	Liabilities and Equity	1983	1984	1985
Current asset				Current liabilities			
Cash in hand and at bank	385.80	824.11	1,243.67	Accounts payable	0.97	9.43	14.76
Accounts receivable (net)	122.31	155.89	160.81	Accrued electricity charge	324.42	298.98	318.15
Advances	2.56	5.64	10.27	Accrued interest	3.73	10.95	19.75
Interest receivable	8.52	31.71	42.74	Other accrued expenses	23.50	5.59	9.51
Inventories	152.60	168.82	161.73	Customers deposits	25.72	31.24	38.10
Work in progress	1.81	3.36	7.90	Employees' deposits	4.96	5.51	6.03
Other current assets	1.55	2.30	2.58	Connection fees received in advance	17.61	36.12	31.11
				Current portion of long term debt	2.87	5.54	42.36
				Other current liabilities	14.63	12.83	14.40
Total current assets	675.15	1,191.83	1,629.70	Total current liabilities	418.41	416.20	494.17
Fixed assets				Long term debt	164.61	513.09	641.26
Land	21.96	34.75	43.46				
Building and construction	1,452.07	1598.93	1907.97				
Equipment	497.77	568.94	594.70				
Sub total	1,971.80	2,202.62	2,546.13				
Less accumulated depreciation and amortization	-334.01	-449.46	-590.35				
Fixed asset (net)	1,637.79	1,753.16	1,955.78	Total liabilities	583.02	929.29	1,135.43
Construction in progress	173.69	258.50	350.18	Equities			
				Capital	2,147.50	2,147.50	2,147.50
Other asset				Government subsidy	1,512.09	1,775.50	2,071.08
Construction advances	20.00	40.17	23.86	Other subsidy	1.91	109.78	109.99
Right of possesion over Government property (net)	957.86	924.17	890.48	Capital surplus (net)	43.20	73.61	90.00
				Capital surplus from donations	-2.04	0.71	0.71
				Total	3,702.66	4,107.10	4,419.28
				Profit (loss) at beginning	-703.21	-821.19	-868.56
				Profit (loss) for the year	-117.98	-47.37	163.85
				Profit (loss) at the end	-821.19	-868.56	-704.71
				Total equities	2,881.47	3,238.54	3,714.57
Total assets	3,464.49	4,167.83	4,850.00	Total liabilities & equuitie	3,464.49	4,167.83	4,850.00