3.6 Financial Status

3.6.1 Present System

As of 1987, the Thung Song Waterworks has 3,799 connections. The annual water production and water sale in 1987 were 1,704,450 and 1,253,329 cu.m, respectively.

PWA has three major sources of tariff revenue: namely water sales, service charges and connection fees. These contributed 95% to the total revenue of PWA. The waterworks has about the same income structure as this. PWA also applies same water rate structure to all waterworks.

Details of the current levels of tariffs are set out in Tables 3-6-1 to 3-6-3.

Table 3-6-1 Present Water Sales Charges

Consumption (cu.m/mo)	Tariff (฿/cu.m)
0 - 10	3.75
11 - 20	4.50
21 - 30	6.50
31 - 50	7.50
51 - 80	8.00
81 - 100	8.50
101 - 300	9.00
301 - 1,000	9.25
1,100 - 2,000	9.50
2,001 - 3,000	9.75
3,001 and above	10.00

Table 3-6-2 Present Service Charge

Size of Conn.	Service Charge (฿/conn.)
1/2"	10
3/4"	15
1"	30
1-1/2"	60
2"	100
2-1/2"	120
3"	160
4" and above	200

Table 3-6-3 Present Connection Charge

Size of Conn.	Basic Connection Fee (฿/conn.)
1/2"	2,050
3/4"	2,750
1"	3,750
1-1/2"	6,690
2"	9,575
2-1/2"	13,075
3"	15,495
4"	21,455
6"	30,025

Note : The basic connection fee is applied to the connection with an installation length of less than 10 m from a main pipe.

3.6.2 Revenue and Expenditure

The annual revenue and expenditure of the waterworks in the last three years are shown in Table 3-6-4.

Table 3-6-4 Revenue and Expenditure

(Unit : 1,000 ฿)

Year	Revenue	Expenditure	Profit(Loss)
1985	8,306	3,582	4,724
1986	9,548	3,413	6,135
1987	9,720	3,841	5,879

In the accounting system of PWA, all the revenues of waterworks are transferred to the PWA Head Office. All the expenses are also allocated by the PWA Head Office. However, as shown in Table 3-6-6, such accounts as capital investment, debt service and depreciation and amortization are not within the waterworks' own financial system.

To identify and quantify the financial status of waterworks, one of the financial ratios (revenue/expenditure) is computed as shown in Table 3-6-5.

Table 3-6-5 Ratio of Revenue to Expenditure

Office	1985	1986	1987
PWA Head Office	1.45	1.72	1.76
Thung Song Waterworks	2.32	2.80	2.53

When this ratio is equal to or greater than 1.0, the financial status of the waterworks is in good condition.

As shown above, the waterworks earned a net profit on its annual operations. Also the ratio is greater than both 1.0 and the average rate of all PWA waterworks.

A breakdown of the revenue and expenditure is shown in Table 3-6-6.

Table 3-6-6 Revenue and Expenditure of Thung Song Waterworks

(Unit : Baht)

Description	1985	1986	1987
Water Production cu.m	1,924,233	1,976,185	1,704,450
Water Sales cu.m	1,331,805	1,193,847	1,253,329
No. of Connections	3,368	3,549	3,799
Revenue			
Water Sales	7,088,811.51	8,063,027.25	8,377,581.00
Service Charge	452,800.00	479,595.00	511,340.00
Connection Fee	737,290.50	984,815.00	805,914.00
Other Revenue	27,083.08	20,811.62	25,297.89
Total Revenue (A)	8,305,985.09	9,548,248.87	9,720,132.89
Expenditure			
Salaries	1,711,980.00	1,647,720.00	1,845,720.00
Remuneration	371,184.55	333,523.70	372,651.79
Chemical	218,000.00	169,395.56	266,098.75
Material & Maintenance	103,557.17	35,799.62	219,409.08
Oil & Fuel	50,015.96	31,530.01	42,558.46
Office Supplies	13,104.36	11,493.01	14,101.35
Hired Service	4,102.22	25,911.02	10,025.00
Other Operating Expense	4,689.50	8,805.50	14,322.00
Public Utilities	48,823.75	6,061.25	9,107.00
Electricity	736,322.91	773,497.46	765,295.67
Connection Cost	314,852.05	366,974.80	278,147.55
Material Sold	4,996.71	1,936.600	3,628.00
Total Expenditure (B)	3,581,629.18	3,412,647.93	3,841,064.65
Profit (Loss)	4,724,355.91	6,135,600.94	5,879,068.24

4. POPULATION AND WATER DEMAND

4.1 Project Horizon

The study area is the town planning area of Thung Song by DTCP and Tambon Na Bon in Amphoe Na Bon.

The town planning area includes the Thung Song Municipality, the area of which is 7.17 sq.km, and neighboring parts of tambons in Amphoe Thung Song where urban expansion from the Municipality may reach.

Tambon Na Bon includes a sanitary district with an area of 4 sq.km which is supplied water from the Thung Song Waterworks at present.

Both the planning area and Tambon Na Bon are thought to be large enough to meet urban expansion by 2011.

The study area of Thung Song is shown in Figure 4-1-1.

4.2 Population

4.2.1 Historical Population

The population of the Thung Song study area was 31,600 in 1987 and that of Tambon Na Bon was 12,600 in 1987 as shown in Table 4-2-1.

Population of the Municipality has shown a slow but steady growing trend since 1983 with an average annual growth rate of 0.7%.

In general, population growth of the neighboring tambons in recent years is also slow.

The Municipality has experienced continuous net out-migration in the 1980's.

Population of the Na Bon Sanitary District shows a growing trend with an average annual growth rate of 1.9% since 1981.

4.2.2 Future Population

Future population was firstly calculated with the following five mathematical formulae:

A) Arithmetical progression $y = aX + b$

B) Geometrical progression $y = y_0 \times (1 + b)^X$

C) Decreasing rate of increase $y = K - ab^X$

D) Exponential $y = y_0 + ax^b$

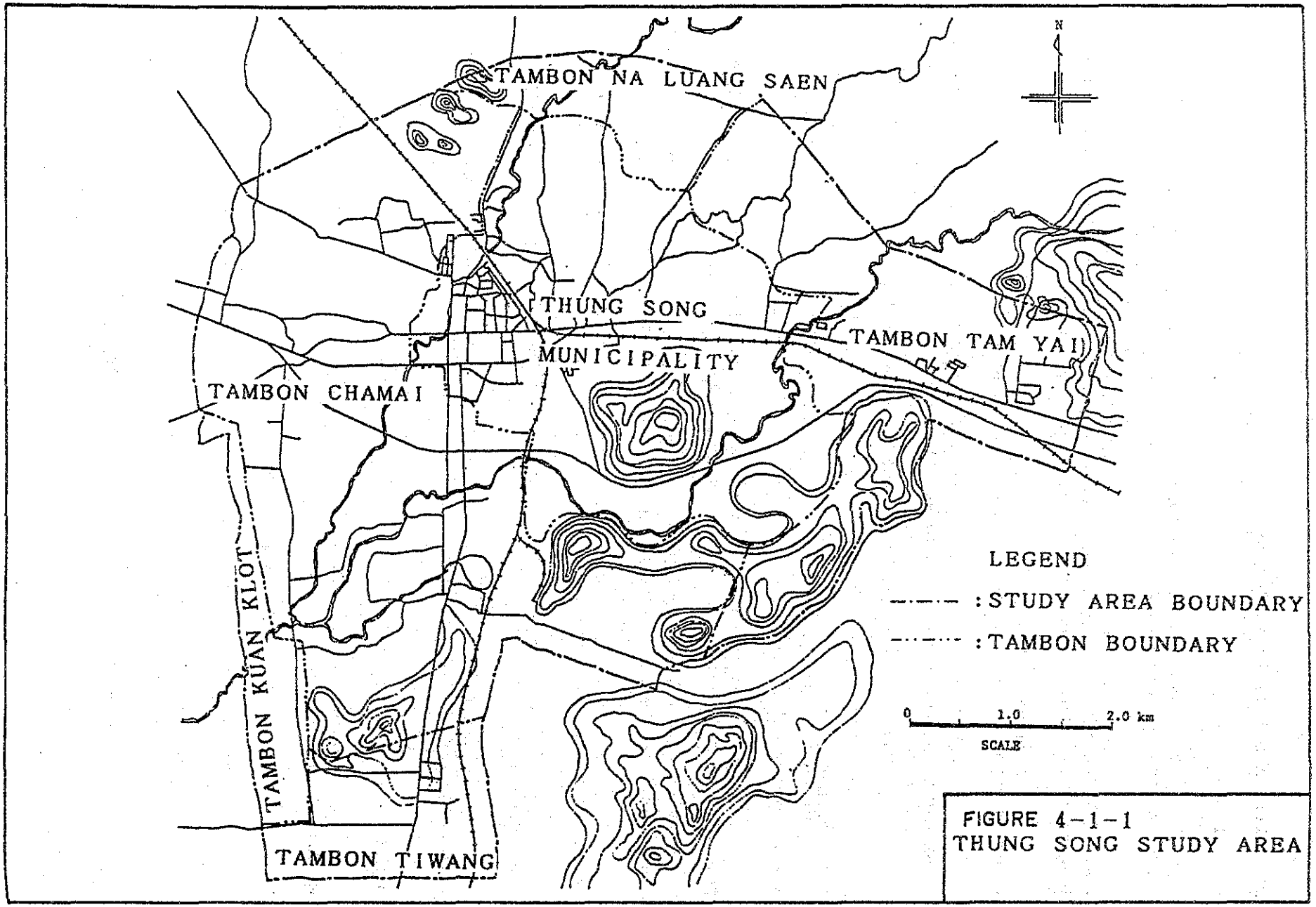


FIGURE 4-1-1
THUNG SONG STUDY AREA

Table 4-2-1 Population Projection of Thung Song and Na Bon Study Areas

Year	1980	1981	1982	1983	1984	1985	1986	1987	1991	1996	2001	2006	2011
Population of Thung Song Municipality													
Population	22,623	23,305	23,747	21,035	21,137	21,324	21,330	21,617	21,707	22,187	23,106	24,516	26,376
Natural Increase (%)		5.994	6.398	6.355	7.787	8.038	7.180	5.541	4.6	3.1	1.5	1.5	1.5
Social Increase (%)		-2.979	-4.501	-17.775	-7.302	-7.153	-7.152	-4.195	-4.375	-2.5	-0.525	-0.15	0
Growth Rate (%)		3.015	1.897	-11.420	0.485	0.885	0.028	1.346	0.225	0.6	0.975	1.35	1.5
Population of Thung Song Study Area								31,644	31,772	32,467	33,803	35,859	38,573
Inside Municipality								21,617	21,707	22,187	23,106	24,516	26,376
A1 *								8,847	8,885	9,085	9,464	1,0043	10,809
A2 *								3,154	3,167	3,236	3,369	3,574	3,844
B1 *								3,875	3,890	3,975	4,139	4,391	4,723
B2 *								1,609	1,615	1,649	1,716	1,820	1,956
B3 *								4,132	4,150	4,242	4,418	4,688	5,044
Outside Municipality								10,027	10,065	10,280	10,697	11,343	12,197
Naluangsaen								656	657	668	694	734	788
Tomyai								3,241	3,254	3,325	3,462	3,672	3,950
Kuanklat								100	100	100	100	105	110
Tiwang								390	390	397	410	433	463
Chamai								5,640	5,664	5,790	6,031	6,399	6,886
Population of Na Bon Sanitary District	3,245	3,213	3,367	3,486	3,450	3,585		3,639	3,928	4,287	4,646	5,004	5,363
Population of Tambon Na Bon					12,665	12,612		12,639	13,645	14,891	16,137	17,383	18,630

* See Figure 4-2-3
Source : "Annual Statistics of Residents Registration" DTCP

E) Logistic $y = k / (1 + \exp(a - bX))$

Where,

y : Population forecasted

y_0 : Population in the base year

X : Years from the base year

a, b, X : Coefficient

Referring to these mathematical models for comparison, future population of the study area was estimated by the following method.

(1) In the Municipality, the natural growth rate is assumed to decrease steadily from the recent level of 5% to 8% to 1.5% in 2001 and will remain at the level. The natural increase rate of 1.5% is the national target for 1986, while the rate in the southern region has been higher than the national average.

The net out-migration will also steadily decrease from the recent level of 4% to 8% to zero percent in 2008 and then in- and out-migration will balance due to efforts to vitalize the Municipality's economic and social activities.

(2) The neighboring tambons in the study area will have equal growth rates to the Municipality.

Tambon Tiwang, as a whole, grew rapidly in recent years but the contribution to the study area is not large due to its small share in the area.

(3) Population of the Na Bon Sanitary District has been increasing at an average growth rate of 1.9% from 1981 to 1987. As available data of past population outside the sanitary district in Tambon Na Bon are limited, the growth rates of the tambon are assumed to be equal to the growth rates of the sanitary district and the future population is calculated by regression analysis. Then results by arithmetical regression are adopted since they are slightly lower than the case of geometrical progression, considering availability of the readily developable land.

Figures 4-2-1 and 4-2-2 show the population projection of the relevant areas for reference. In those figures, legends "A" to "E" correspond to the formulae and the legend "T" shows the values adopted.

Based on the above assumptions, population of the total study area in 2011 is estimated at 57,200 consisting of 38,600 in the Thung Song area and 18,600 in Tambon Na Bon as in Table 4-2-1.

As in Table 4-2-2, presently the average family size is approximately 4.90 in the Thung Song study area and 6.03 in Tambon Na Bon. According to the HOMES Research Report prepared in 1987 for the Seminar on Demographic and Economic Forecast for Thailand, the average householdsize of the nation in 2011 will be approximately 71% of the 1987 level. Following the decreasing trend, the figure in 2011 is estimated at 3.50 in the Thung Song study area and 4.31 in Tambon Na Bon.

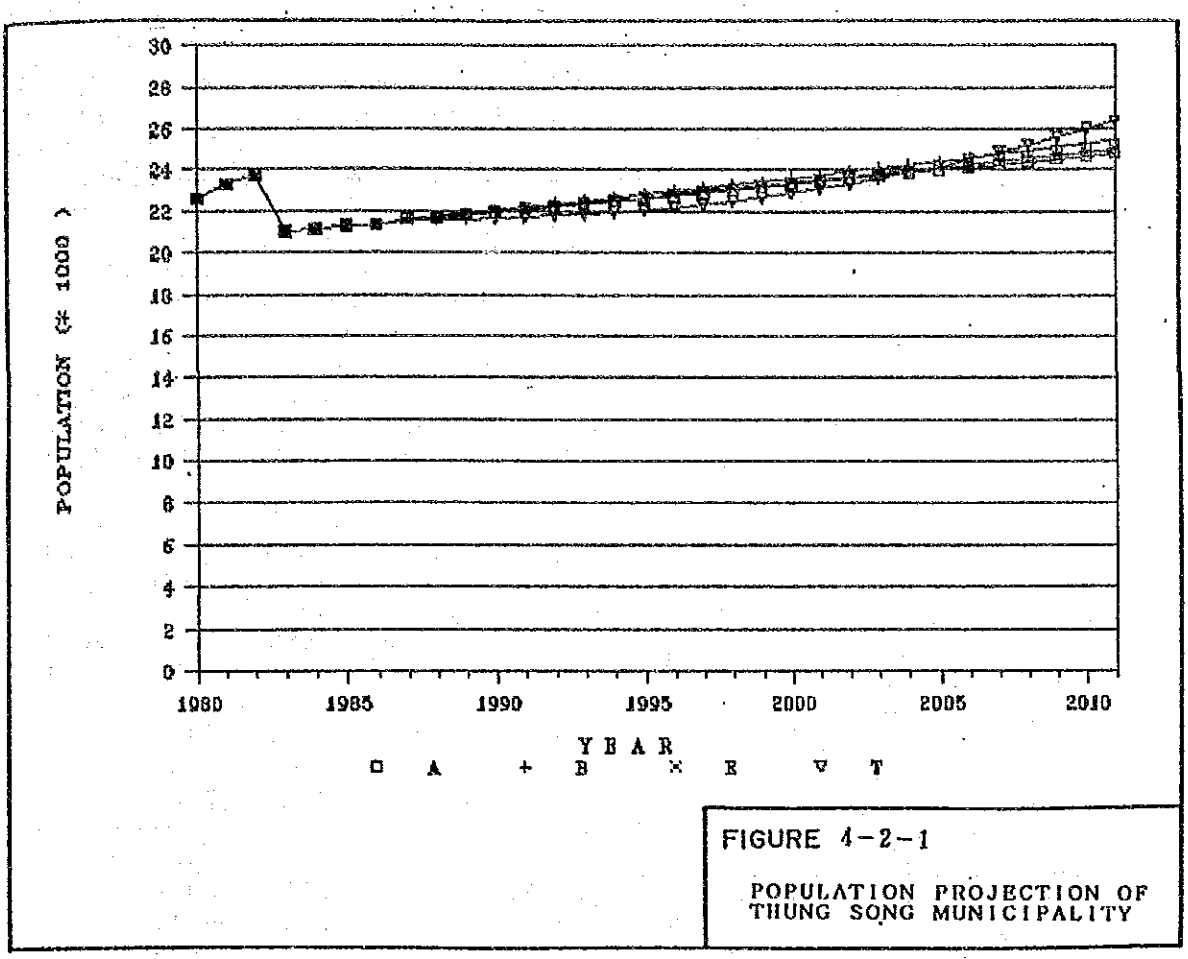


FIGURE 4-2-1

POPULATION PROJECTION OF THUNG SONG MUNICIPALITY

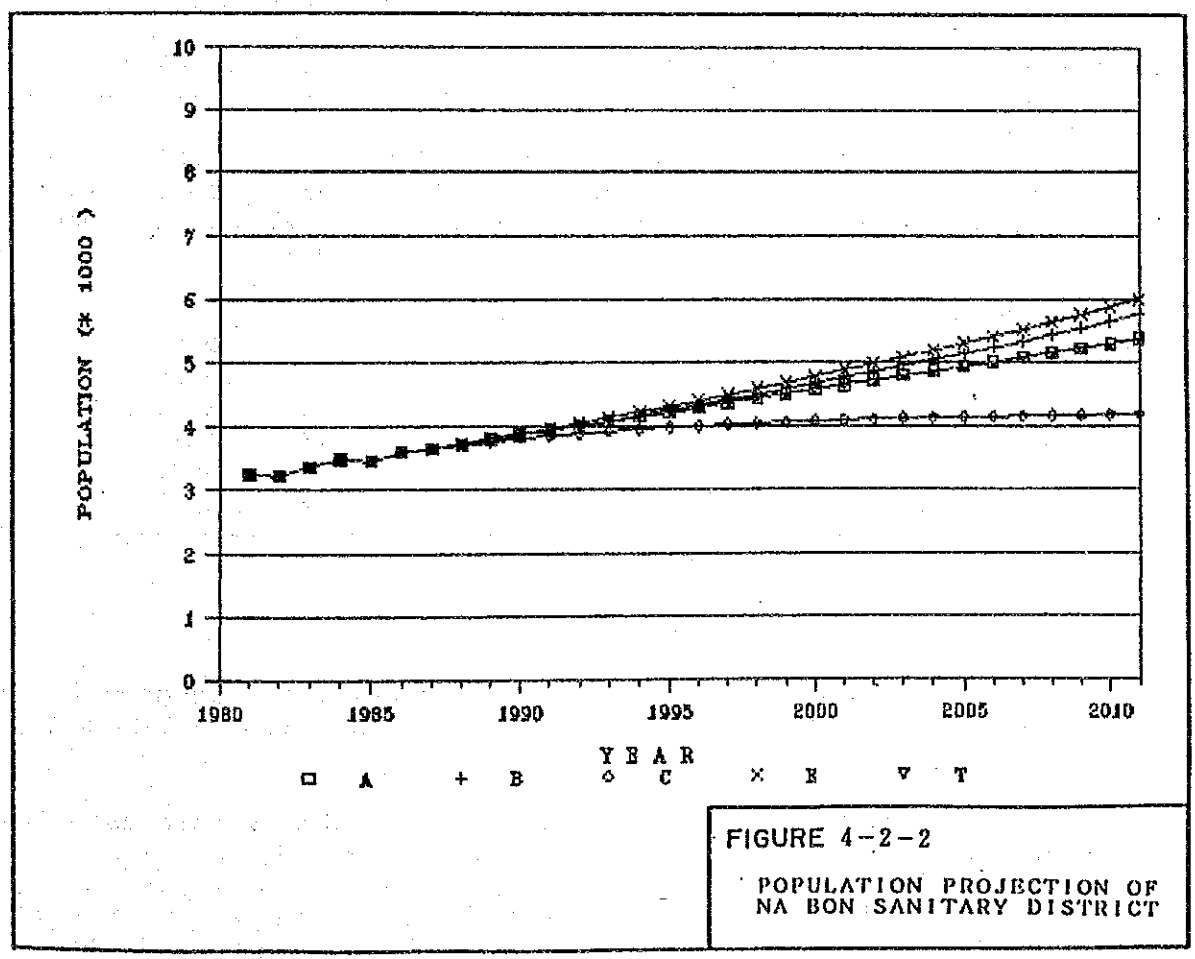


FIGURE 4-2-2

POPULATION PROJECTION OF NA BON SANITARY DISTRICT

The numbers of families in 2011 are estimated at 11,000 in the Thung Song study area and 4,300 in Tambon Na Bon.

The numbers of houses in 2011 are estimated at 13,000 in Thung the Song study area and 3,900 in Tambon Na Bon.

Table 4-2-2 Numbers of Families and Houses

Thung Song Municipality								
Year	1980	1981	1982	1983	1984	1985	1986	1987
Population	22623	23305	23747	21035	21137	21324	21330	20719
No. of Houses	3908	4011	4118	5125	5232	5321	5477	5211
House Size	5.79	5.81	5.77	4.10	4.04	4.01	3.89	3.98
Nation (HOMES Research Report, Nov. 1987)								
Year		1985	1990	1995	2000	2005	2010	2015
Household Size		4.98	4.62	4.27	3.96	3.7	3.49	3.31
Year		1987	1991	1996	2001	2006	2011	
Household Size		4.84	4.55	4.21	3.91	3.66	3.45	
Index		1	0.94	0.87	0.81	0.76	0.71	
Thung Song								
Year		1987	1991	1996	2001	2006	2011	
Population		31644	31772	32467	33803	35859	38573	
Family Size		4.90	4.61	4.27	3.96	3.71	3.50	
No. of Families		6453	6886	7608	8530	9667	11013	
House Size		4.16	3.91	3.62	3.36	3.14	2.97	
No. of Houses		7611	8122	8974	10060	11402	12989	
Na Bon Sanitary District								
Year		1981	1982	1983	1984	1985	1986	1987
Population		3245	3213	3367	3486	3450	3585	3639
No. of Houses		389	394	401	407	410	495	495
House Size		8.34	8.15	8.40	8.57	8.41	7.24	7.35
Tambon Na Bon								
Year		1987	1991	1996	2001	2006	2011	
Population		12639	13645	14891	16137	17383	18630	
Family Size		6.03	5.67	5.25	4.87	4.56	4.31	
No. of Families		2096	2405	2838	3311	3811	4325	
House Size		6.67	6.28	5.80	5.39	5.04	4.76	
No. of Houses		1895	2174	2565	2993	3445	3910	

4.2.3 Higher and Lower Growth Cases

In order to compare effects of the assumptions adopted in the method of estimation, higher and lower growth cases are shown in Tables 4-2-3 and 4-2-4.

Of the Thung Song study area, in the higher growth case, the natural growth rate is assumed to decrease steadily to 1.5% in 2006, 5 years after the original case and the net out-migration is assumed to decrease steadily to stop in 2003, 5 years before the original case, and to change to out-migration which increases by the same rate of the decrease of the out-migration.

In the lower growth case, the natural growth rate is assumed to decrease steadily to 1.5% in 1996, 5 years before the original case and the net out-migration is assumed to decrease steadily to stop in 2011, 3 years after the original case.

In the higher growth case, the population of the area is 35% more than the original case, while in the lower growth case, it is 15% less.

Of Tambon Na Bon, in the higher growth case, the annual increment is assumed to be 274 persons, which is 10% more than the original case, while in the lower growth case, the increment is assumed to be 224 persons, which is 10% less than the original case. In both cases, constant factors are adjusted so as to give the same results as the original case in 1987.

In the higher growth case, the population of the tambon is 3% more than the original case, while in the lower growth case, it is 3% less.

Table 4-2-3 Population of Thung Song Study Area

	1987	1991	1996	2001	2006	2011
Original Case						
Thung Song S.A.	31644	31772	32467	33803	35859	38573
Municipality	21617	21707	22187	23106	24516	26376
Outside Mun.	10027	10065	10280	10697	11343	12197
Higher Growth Case						
Thung Song S.A.	31644	33523	36431	40079	44632	51896
Municipality	21617	22904	24897	27394	30512	35483
Outside Mun.	10027	10619	11534	12685	14120	16413
Lower Growth Case						
Thung Song S.A.	31644	32471	31523	30568	30966	32766
Municipality	21617	22184	21542	20893	21170	22405
Outside Mun.	10027	10287	9981	9675	9796	10361

Table 4-2-4 Population of Tambon Na Bon

	1987	1991	1996	2001	2006	2011
Original Case	12639	13645	14891	16137	17383	18630
Higher Growth Case	12639	13745	15116	16487	17858	19228
Lower Growth Case	12639	13546	14667	15789	16910	18032

4.2.4 Population Distribution

In Thung Song, the most densely populated area is the northern district of the old Route 403 in the Municipality. Outside the Municipality, the town of Tomyai is the only one district where considerable population accumulation is observed while other areas have only scattered villages.

Future population distribution will be guided by the land use plan of DTCP to be finalized in 1989. However, by assuming equal growth rates for all the districts, population distribution in 2011 can be roughly estimated as in Table 4-2-1 and Figure 4-2-3.

In Na Bon, population of the sanitary district accounts for 28.8% of the tambon population in 1987.

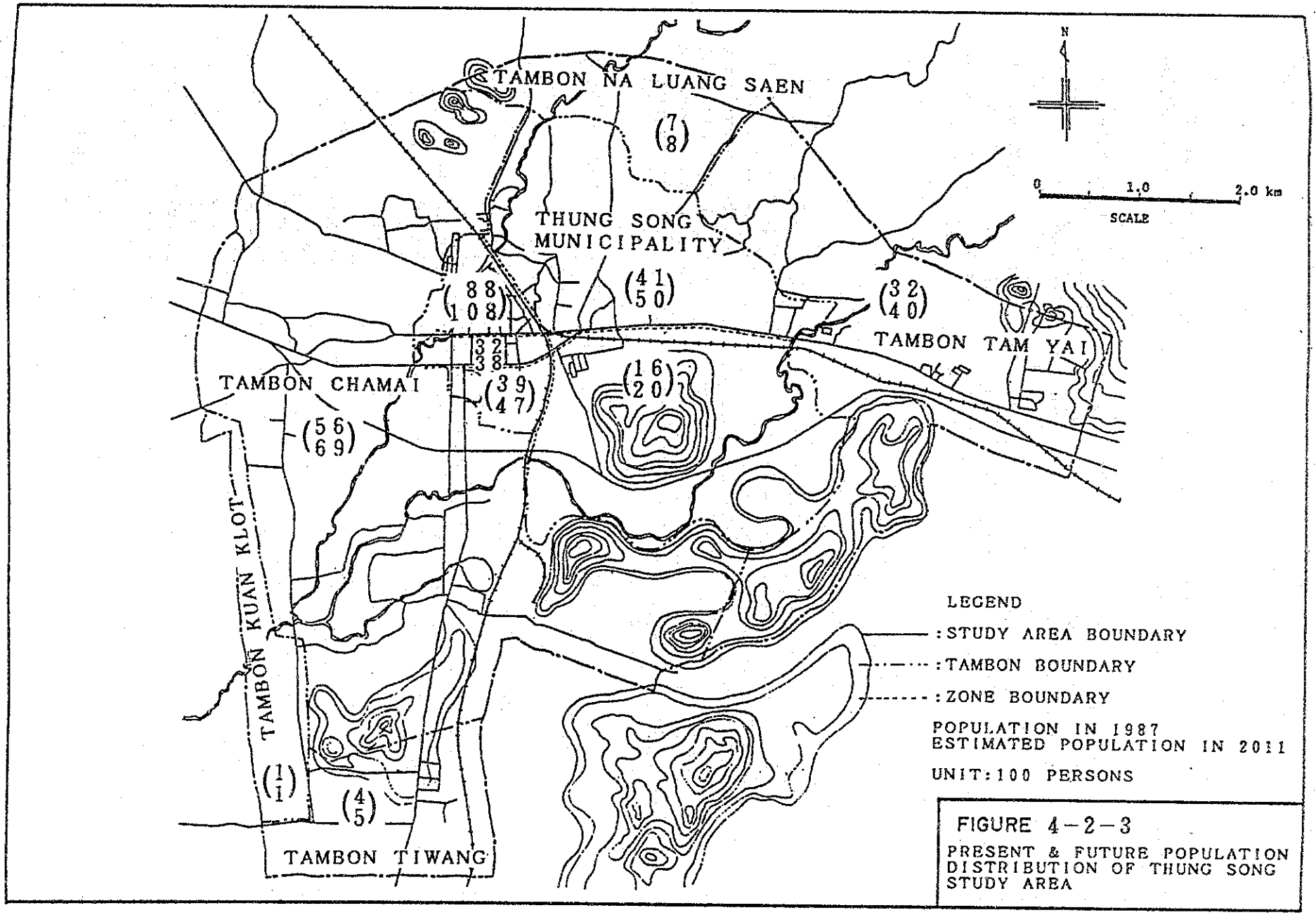


FIGURE 4-2-3
PRESENT & FUTURE POPULATION DISTRIBUTION OF THUNG SONG STUDY AREA

4.3 Service Area and Served Population

4.3.1 Service Area

The present service area of the Thung Song Waterworks consists of the Municipality of Thung Song and the Sanitary District of Na Bon in Amphoe Na Bon.

For the expansion of the services area in the future, taken into account are the DTCP's development plan and the PWA's development strategy. Consideration is made with future land use, and population growth.

The future service area is classified into three categories: (1) the Thung Song Municipality, (2) outside the Municipality, and (3) the Na Bon Sanitary District. The extent of the service area in year 2011 is as shown in Figure 4-3-1.

4.3.2 Served Population

(1) Past and Present Served Population

Past and present served population was estimated from the number of connections and the number of members per household. Prior to this, the number of connections for domestic use was calculated from the number of connections in the past, and the ratio of the connections for domestic use against the total connections. As the ratio of residential users is 0.964 (see Table 4-4-4), this ratio is applied to each year's number of connections to calculate the number of connections for domestic use.

Table 4-3-1 shows the result of estimation of served population in each year.

Table 4-3-1 Estimation of Served Population

Year	No. for Conn. (a)	No. of Conn. for Domestic Use (b)	Pop./ No. of Houses (c)	Population Served (d)
1980	2,799	2,704	5.79	15,656
1981	2,926	2,827	5.81	16,425
1982	3,024	2,921	5.77	16,854
1983	3,126	3,021	4.1	12,382
1984	3,196	3,087	4.01	12,379
1985	3,368	3,253	4.01	13,045
1986	3,549	3,428	3.89	13,335
1987	3,799	3,670	3.98	14,607

(c) = (b) x 0.966

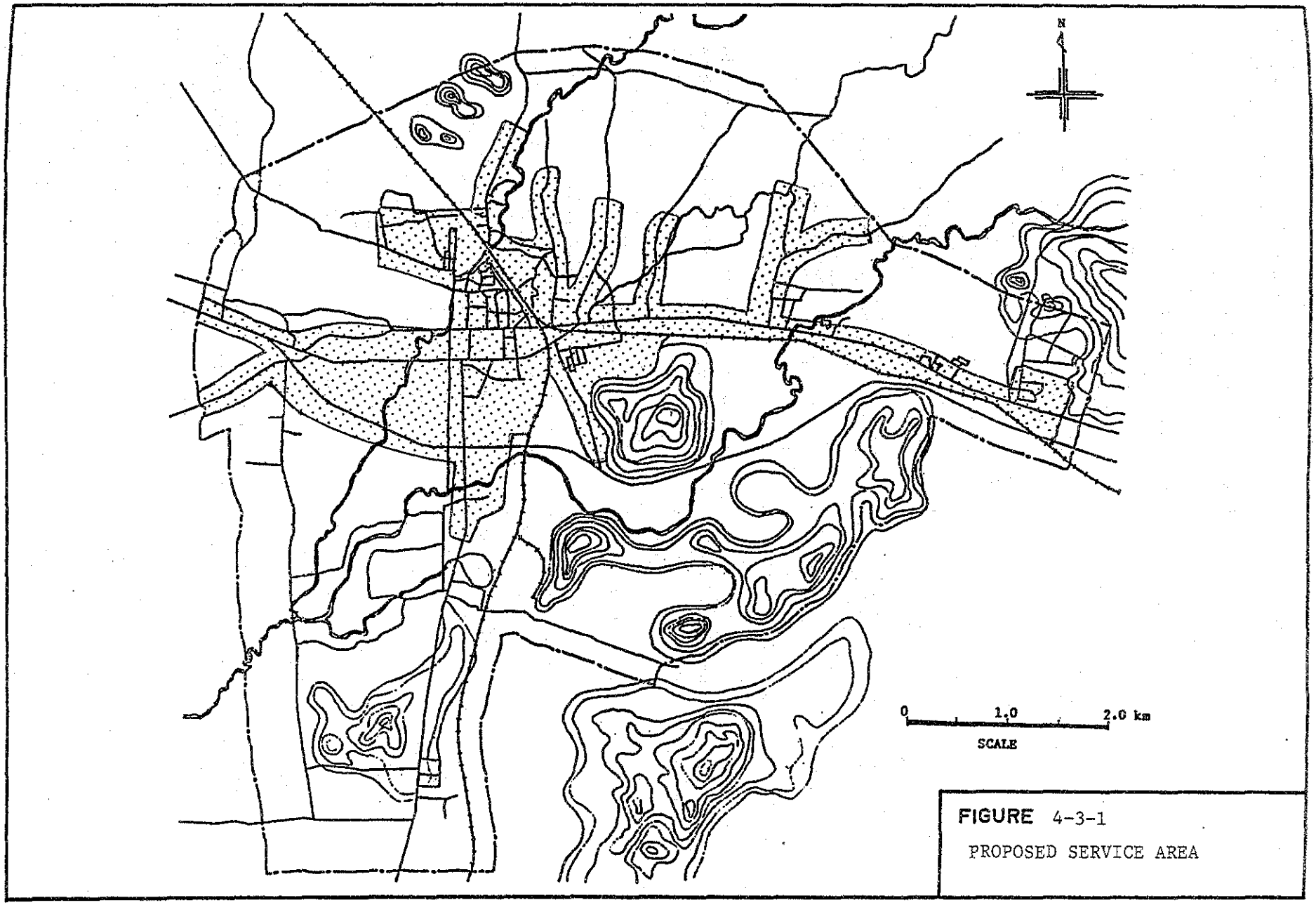


FIGURE 4-3-1

PROPOSED SERVICE AREA

(2) Service Ratio

Service ratio is given as shown in Table 4-3-2

Table 4-3-2 Estimation of Service Ratio

Year	Total Population in Service Area	Population Served	Service Ratio (%)
1980	22,623	15,656	69.2
1981	23,305	16,425	70.5
1982	23,747	16,854	71.0
1983	21,035	12,382	58.9
1984	21,137	12,379	58.6
1985	21,324	13,045	61.2
1986	21,330	13,335	62.5
1987	20,719	14,607	70.5

(3) Future Service Ratio Forecasting

The future service ratio by area are scheduled considering the present service ratio and land use plan, and are summarized as shown in Table 4-3-3.

Table 4-3-3 Future Service Ratio

(Unit : %)

Year	Thung Song		Na Bon
	Municipality	Fringe Area	
1991	70	10	50
1996	73	23	55
2001	75	35	60
2006	78	48	65
2011	80	60	70

(4) Future Served Population

Future served populations are calculated by area using the future service ratios and projected population therein as shown in Table 4-3-4.

Table 4-3-4 Future Served Population

Year	Thung Song		Na Bon	Total	Average Service Ratio (%)
	Mun.	Fringe Area			
1991	15,195	503	1,965	17,663	57.6
	(21,707)	(5,033)	(3,930)	(30,670)	
1996	16,197	1,182	2,359	19,738	62.4
	(22,187)	(5,140)	(4,289)	(31,616)	
2001	17,330	1,872	2,788	21,990	66.4
	(23,106)	(5,349)	(4,647)	(33,102)	
2006	19,122	2,723	3,254	25,099	71.3
	(24,516)	(5,672)	(5,006)	(35,194)	
2011	21,101	3,659	3,756	28,516	75.4
	(26,376)	(6,099)	(5,365)	(37,840)	

Upper : Served population in the service area
Lower : Total population in the service area

4.4 WATER DEMAND

4.4.1 Historical Water Consumption

(1) Water Production and Sales

The annual water production and sales from 1980 to 1987 are shown in Figure 4-4-1 and Table 4-4-1.

Table 4-4-1 Annual Water Production and Sales

Year	Water Production (cu.m/y)	Water Sales (cu.m/y)	No. of Conn.	Consump. per Conn. (cu.m/d)
1980	1,367,406	1,138,162	2,799	1.111
1981	1,437,426	1,114,069	2,926	1.043
1982	1,623,228	1,336,872	3,024	1.211
1983	1,643,726	1,339,385	3,126	1.174
1984	1,773,604	1,397,133	3,196	1.194
1985	1,924,233	1,331,805	3,368	1.083
1986	1,976,185	1,193,847	3,549	0.922
1987	1,704,450	1,253,329	3,799	0.904

(2) Classification of Consumption

PWA Survey Reports from 1985 to 1987 shows the consumption by categorized major consumer as listed in Table 4-4-2. Table 4-4-3 shows the average of three years after being regrouped into five groups for convenience of estimating future water demand.

4.4.2 Future water consumption

The five categories of consumption listed in Table 4-4-3 will be forecasted separately for future, as they are different in nature.

(1) Domestic Water Consumption

Table 4-4-3 shows that the average domestic water consumption is accounted to be 58.4% of the total consumption. Assuming that this ratio has been constant from 1980 to 1987, the domestic water consumption is calculated as shown in Table 4-4-4.

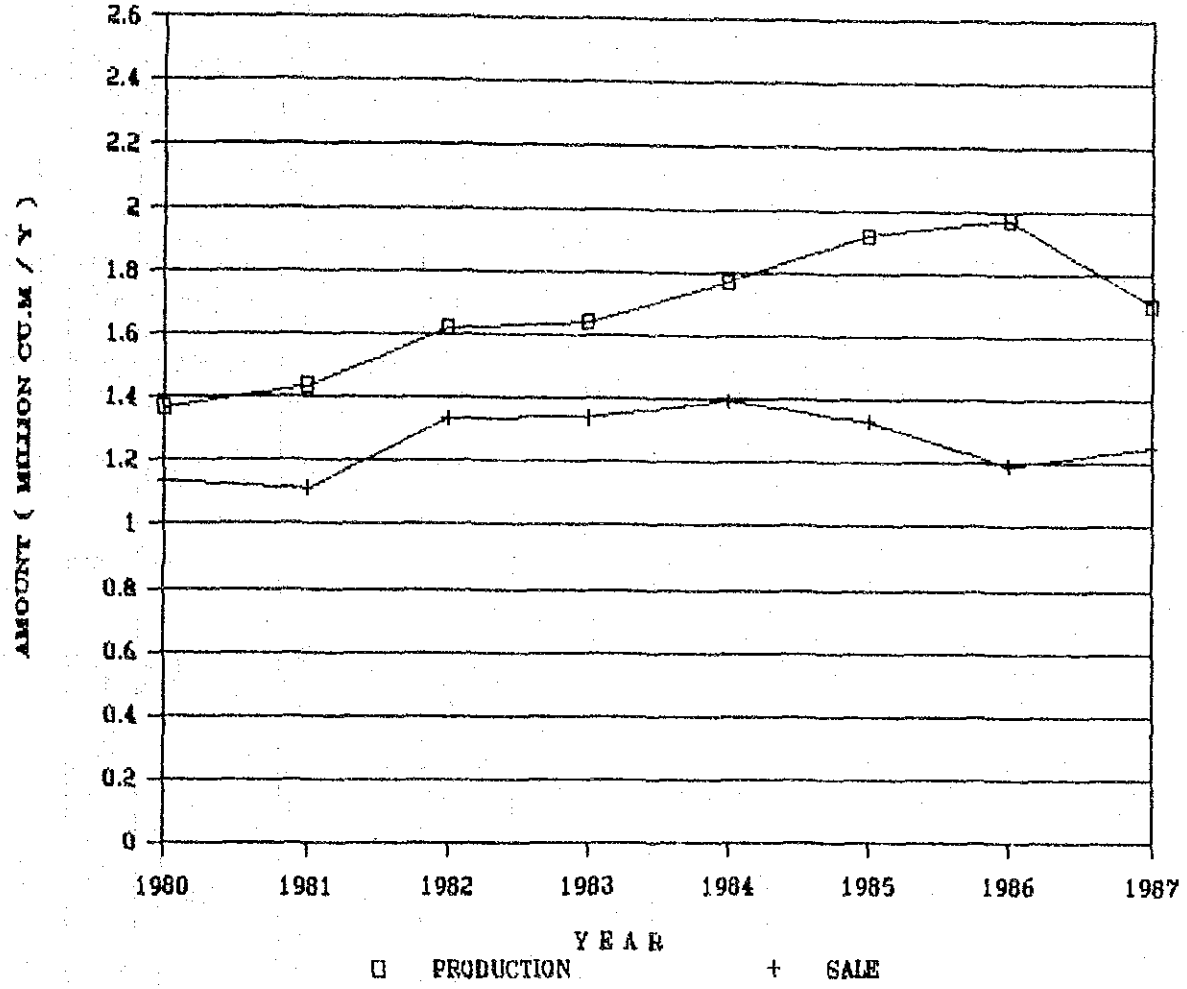


FIGURE 4-4-1

WATER PRODUCTION/SALE
THUNG SONG

Table 4-4-2 Major Consumers by Category

Code	Category	1985		1986		1987		Total		Average		Share	
		No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.
1	Residential	27	1707	27	1153	30	1423	84	4283	28	1428	0.78	1.48
2	Residential(Rental)	3	312	6	653	8	696	17	1661	5.7	554	0.16	0.58
3	Commercial	38	1811	40	1913	48	2470	126	6194	42	2065	1.17	2.15
4	Restaurant	7	918	7	930	10	1214	24	3062	8	1021	0.22	1.06
5	Government Agency	25	28721	28	29228	29	31836	82	89785	27.3	29928	0.76	31.1
6	School	10	2855	12	2335	12	2745	34	7935	11.3	2645	0.32	2.75
7	Temple	0	0	0	0	0	0	0	0	0	0	0	0
8	Bangalow	0	0	0	0	0	0	0	0	0	0	0	0
9	Industrial	11	1344	10	1160	10	1496	31	4000	10.3	1333	0.29	1.39
10	Hotel	9	1573	10	1815	10	2046	29	5434	9.7	1811	0.27	1.88
11	Hospital	3	200	3	426	3	314	9	940	3	313	0.08	0.33
12	Service	0	0	3	144	0	0	3	144	1	48	0.03	0.05
13	Others	3	582	0	0	4	208	7	790	2.3	263	0.07	0.27
	Sub-total	136	40023	146	39757	164	44448	446	124228	148.7	41409	4.15	43.03
	Percentage	4.09	42.78	4.04	43.76	4.32	42.63	4.15	43.03				
14	Other than Major Consumer	3191	53536	3466	51096	3635	59822	10292	164454	3430.7	54818	95.85	56.97
	Sub-total	3191	53536	3466	51096	3635	59822	10292	164454	3430.7	54818	95.85	56.97
	Percentage	95.91	57.22	95.96	56.24	95.68	57.37	95.85	56.97				
	Total	3327	93559	3612	90853	3799	104270	10738	288682	3579.3	96227		
	Percentage	100	100	100	100	100	100	100	100			100	100

Table 4-4-3 Water Consumption by Category (after Re-grouping)

Code	Category	1985		1986		1987		Total		Average		Share	
		No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.	No. of Conn.	Consump.
	Domestic												
1	Residential	27	1707	27	1153	30	1423	84	4283	28	1428	0.78	1.48
14	Other than Major Consumer	3191	53536	3466	51096	3635	59822	10292	164454	3430.7	54818	95.85	56.97
	Sub-total	3218	55243	3493	52249	3665	61245	10376	168737	3458.7	56246	96.63	58.45
	Institutional												
5	Government Agency	25	28721	28	29228	29	31836	82	89785	27.3	29928	0.76	31.1
6	School	10	2855	12	2335	12	2745	34	7935	11.3	2645	0.32	2.75
7	Temple	0	0	0	0	0	0	0	0	0	0	0	0
11	Hospital	3	200	3	426	3	314	9	940	3	313	0.08	0.33
	Sub-total	38	31776	43	31989	44	34895	125	98660	41.7	32887	1.16	34.18
	Commercial												
3	Commercial	38	1811	40	1913	48	2470	126	6194	42	2065	1.17	2.15
4	Restaurant	7	918	7	930	10	1214	24	3062	8	1021	0.22	1.06
8	Bangalow	0	0	0	0	0	0	0	0	0	0	0	0
10	Hotel	9	1573	10	1815	10	2046	29	5434	9.7	1811	0.27	1.88
	Sub-total	54	4302	57	4658	68	5730	179	14690	59.7	4897	1.67	5.09
	Industrial												
9	Industrial	11	1344	10	1160	10	1496	31	4000	10.3	1333	0.29	1.39
	Sub-total	11	1344	10	1160	10	1496	31	4000	10.3	1333	0.29	1.39
	Others												
2	Residential(Rental)	3	312	6	653	8	696	17	1661	5.7	554	0.16	0.58
12	Service	0	0	3	144	0	0	3	144	1	48	0.03	0.05
13	Others	3	582	0	0	4	208	7	790	2.3	263	0.07	0.27
	Sub-total	6	894	9	797	12	904	27	2595	9	865	0.25	0.9
	Total	3327	93559	3612	90853	3799	104270	10738	288682	3579.3	96227	100	100.01

Table 4-4-4 Domestic Water Consumption

Year	Water Sales			Pop. Served	Per Capita Consump.
	Total (cu.m/y) (a)	Total (cu.m/d) (b)	Domestic (cu.m/d) (c)	(d)	(lpcd) (e)
1980	1,138,162	3,110	1,816	15,656	116
1981	1,114,069	3,052	1,782	16,425	108
1982	1,336,872	3,663	2,139	16,854	127
1983	1,339,385	3,670	2,143	12,382	173
1984	1,397,133	3,817	2,229	12,379	180
1985	1,331,805	3,649	2,131	13,045	163
1986	1,193,847	3,271	1,910	13,335	143
1987	1,253,329	3,434	2,005	14,607	137

(c) = (b) x 0.584

The estimated per capita consumption for 2011 is assumed to be 200 lpcd in the Municipality of Thung Song.

For per capita consumption in the fringe area and Na Bon in 2011 are assumed to be 140 and 180 lpcd, respectively.

Table 4-4-5 summarizes the unit consumption for domestic use.

Table 4-4-5 Unit Domestic Water Consumption

(Unit : lpcd)

Year	Thung Song		Na Bon
	Municipality	Fringe Area	
1991	170	100	160
1996	178	110	165
2001	185	120	170
2006	193	130	175
2011	200	140	180

Table 4-4-6 shows the domestic water consumption in every five years to 2011.

Table 4-4-6 Future Domestic Water Consumption

(Unit : cu.m/d)

Year	Thung Song		Na Bon	Total
	Municipality	Fringe Area		
1991	2,583	50	314	2,947
1996	2,883	130	389	3,402
2001	3,206	225	474	3,905
2006	3,691	354	569	4,614
2011	4,220	512	676	5,408

(2) Governmental/Institutional Water Consumption

The governmental/institutional water consumption includes the consumption of such institutions as government offices, hospitals, schools and temples.

Water consumption of each institution is predicted separately as they are different in nature.

(a) Governmental Office

It is assumed that the activities of governmental facilities correlate the population of the service area where these facilities are governing. For example, the staff of the police department will be increased as the population grows up.

Considering this concept, future water consumption of the governmental facilities is predicted from the ratio to the total population in the service area of each year. Present data gives the following figures for the water consumption of government offices.

Average consumption of governmental office (1985-1987)

$Q = 29,928$ cu.m/mo

Total population in the service area (1987)

$p = 20,719$

Average daily consumption of governmental office expressed by per population is:

$q = Q/p = 29,928 / 30 / 20,719 = 48$ lpcd

Considering this value, future unit consumption is set as 48 lpcd.

(b) School

Prediction of water consumption of school is made by assuming the number of students from the proportion of that against the total population. The per student consumption calculated from the present data is applied to the future prediction.

Average consumption of school (1985-1987)

$Q = 2,645$ cu.m/mo

Number of students (1987)

n = 2,657 (Municipality) + 5,309 (Amphoe Na Bon) = 7,966

Average daily consumption of student expressed by per school are:

q = Q/n = 2,645 / 30 / 7,966 = 11.1 lpcd

For future unit consumption, 20 lpcd is applied constantly through the years.

(c) Hospital

Most of hospitals in the study area are equipped with their own water sources, mainly deep wells, as well as treatment facilities. This fact makes it difficult to identify the unit consumption and the actual total consumption of hospitals.

Regarding the statistical data of the number of beds against population, the "Population and Health" report of TDRI shows the following historical data with predictions in 1991 and 2006.

Table 4-4-7 Ratio of Population to Hospital Bed

(Unit : pop/bed)

Year	Whole Kingdom	BMA	Provincial Area
1980	805.85	341.48	955.66
1981	801.35	361.22	952.75
1982	793.46	365.63	934.51
1983	761	376	888
1984	749	354	879
1985	748	336	862
1986	744	356	862
1991			(700)
2006			(600)

The ratio of population to bed in the whole of Nakhon Si Thammarat Province was 1,791.04 in 1985, while there is 90 beds in Thung Song for an population of 21,330 in 1986. Therefore, The ratio is 237 pop./bed which is already lower than the national target of 600 pop./bed. No additional bed is accordingly considered to be provided until 2011.

Assuming that water consumption per bed is 1.5 cu.m/d/bed constantly through years, the total consumption is calculated as follows:

(d) Summary of Governmental/Institutional Consumption

The total of governmental/institutional consumption are summarized as shown in Table 4-4-8.

Table 4-4-8 Summary of Governmental/Institutional Consumption

Item	1985-1987	1991	1996	2001	2006	2011
1. Government						
o per pop. consump. (lpcd)	48	48	48	48	48	48
o population in service area	20,719	30,670	31,616	33,102	35,194	37,840
o consump. (cu.m/d)	998	1,472	1,518	1,589	1,689	1,816
2. School						
o per student consump. (lpcd)	11.1	20	20	20	20	20
o No. of students		5,516	5,686	5,954	6,330	6,806
o consump. (cu.m/d)		110	114	119	127	136
3. Hospital						
o per bed consump. (cu.m/d/bed)	0.47	1.5	1.5	1.5	1.5	1.5
o No. of beds	22	90	90	90	90	90
o consump. (cu.m/d)	10	135	135	135	135	135
Total consumption (cu.m/d)	1,096	1,717	1,767	1,843	1,951	2,087

(3) Commercial Water Consumption

Commercial water consumption is defined to be the consumption by private businesses such as shops, restaurants, bars, and markets. Consumption derived from the commercial activities in Thung Song is considered to relate to the population in the service area.

Unit consumption of commercial use is estimated from the 1985-1987 data as follows:

4,897 / 30 / 20,719 = 7.88 lpcd

For future unit consumption, 10 lpcd is adopted.

Table 4-4-9 Commercial Consumption

Year	Population in Service Area	Unit Consump. (lpcd)	Commercial Consump. (cu.m/d)
1991	30,670	10	307
1996	31,616	10	316
2001	33,102	10	331
2006	35,194	10	352
2011	37,840	10	378

(4) Industrial and Other Water Consumption

Presently, water consumption for industrial and other uses is 1.5% and 1.0% to the total of domestic and institutional consumption, respectively. There is no sign for the industry in this region to largely grow up in the future. Therefore, future industry water consumption is assumed to be stable.

For future industrial and other consumptions, 1.5% and 1.0% are applied to the total of domestic and institutional consumption, respectively, as shown below:

Table 4-4-10 Industrial and Other Consumption

(Unit : cu.m/d)

Year	Domestic & Institutional (a)	Industrial (b)	Others (c)
1991	4,664	70	47
1996	5,169	78	52
2001	5,748	86	57
2006	6,565	98	66
2011	7,495	112	75

(b) = (a) x 0.015
(c) = (a) x 0.010

(7) Unaccounted-for Water Ratio

Unaccounted-for water ratio of Thung Song shows rather low value from 1980 and 1987 except for 1985 to 1986 as shown in Table 4-4-11.

This ratio is supposed to be maintained low by implementing the daily maintenance works such as replacement of old pipes, leakage detection, and replacement of water meters with more sensitive and anti-reverse rotation type.

Table 4-4-11 Unaccounted-for Water Ratio

(Unit : %)

Year	Water Production (cu.m/y)	Water Sales (cu.m/y)	Unaccounted-for Water Ratio (%)
1980	1,367,406	1,138,162	16.76
1981	1,437,426	1,114,069	22.50
1982	1,623,228	1,336,872	17.64
1983	1,643,726	1,339,385	18.52
1984	1,773,604	1,397,133	22.23
1985	1,924,233	1,331,805	30.79
1986	1,976,185	1,193,847	39.59
1987	1,704,450	1,253,329	26.47

Considering the past record, the future ratio is set as follows:

Table 4-4-12 Future Unaccounted-for Water Ratio

(Unit : %)

Year	Unaccounted-for Water Ratio
1991	25
1996	23
2001	22
2006	21
2011	20

4.4.3 Future Water Demand

(1) Peak Factor

The data from January 1987 to December 1988 were studied and the results of analysis on the peak factor are summarized in Table 4-4-13.

Since the master meter has not worked well from time to time, some unreliable data were eliminated from the analysis with those recorded by the new master meter installed on October 16,1988.

The biggest peak factor in 1987 is outstanding in comparison with the second one in the same year and that in 1988. A value of 1.30 is therefore adopted as the peak factor to calculate the daily maximum water demand.

Table 4-4-13 Performance of Peak Factor

Item	1987			1988		
	Demand (cu.m/d)	Factor	Date	Demand (cu.m/d)	Factor	Date
Daily Max.	5,607	1.401	Feb. 4	5,226	1.254	Oct. 17
Monthly Max.	4,894	1.223	Feb.	4,845	1.162	Sep.
Daily Ave.	4,002	1		4,169	1	
Monthly Min.	3,386	0.846	Dec.	3,515	0.843	Jan.
Daily Min.	1,334	0.333	Apr. 10	1,055	0.253	Jun. 17

(2) Future Water Demand

Future water demand is calculated from the water consumption, unaccounted-for water ratio, and peak factor.

Table 4-4-14 shows the daily average and maximum water demands.

Table 4-4-14 Future Water Demand

(Unit : cu.m/d)

Category	1987	1991	1996	2001	2006	2011
Domestic	2,013	2,947	3,402	3,905	4,614	5,408
Gov'l/Inst'l	1,154	1,717	1,767	1,843	1,951	2,087
Commercial	186	307	316	331	352	378
Industrial	51	70	78	86	98	112
Others	35	47	52	57	66	75
Sub-Total	**3,439**	**5,088**	**5,615**	**6,222**	**7,081**	**8,060**
Unaccounted-for Water Ratio (%)	26.5	25	23	22	21	20
Unaccounted-for Water	1,238	1,696	1,677	1,755	1,882	2,015
Daily Average	**4,677**	**6,784**	**7,292**	**7,977**	**8,963**	**10,075**
Peak Factor		1.30	1.30	1.30	1.30	1.30
Daily Maximum		**8,819**	**9,480**	**10,370**	**11,652**	**13,098**

5. DESIGN CRITERIA

5.1 Intake

Intake Capacity = 110 percent of the daily maximum demand

5.2 Treatment and Pipe Design

Design criteria for the design of the treatment system and pipeline was established on the basis of the various design standards having been employed in Thailand or other countries, and with consideration on the conditions of the project site and raw water quality.

The design criteria is summarized in the followings:

(1) Water Loss

Intake Loss : 10 %

Treatment Loss : 8 % of production capacity for filter washing and in-plant use.

(2) Pipeline

Formula for Flow Rate Calculation :

Hazen-William's Formula, C = 110

C-value for pipes are usually defined as 130 for new pipes. For planning purpose, 110 is adopted considering miscellaneous loss in line at valves, bends etc.

Velocity : Maximum 3.0 m/s

Minimum 0.3 m/s

Pipe Material: Material should be decided considering pressure, soil condition, pipe profile, etc. However, material is generally selected in accordance with the principle below:

Steel Pipe:for diameter 400 mm or larger

A/C Pipe: for diameter 300 mm or smaller

(3) Treatment Plant Facilities

a. Receiving Well

Retention Time : 1.5 min

b. Mixing Tank

Type of mixing	:	Hydraulic
Mixing time (min)	:	1 - 5
Intensity, G (1/sec)	:	500 - 1,000

c. Flocculation

Type of mixing	:	Hydraulic
Stage	:	3 or more
Intensity, G (1/sec)	:	10 - 75
Flocculation time (min)	:	20 - 40

d. Sedimentation Basin

Type of sedimentation	:	by Gravity
Type of basin	:	Rectangular Horizontal flow
Flow velocity (cm/min)	:	less than 40
Retention time (hour)	:	3 - 5
Effective depth (m)	:	3 - 4
Length/Width ratio	:	3 - 8
Sludge removal	:	by manual

e. Filter

Type of filtration	:	Rapid sand filtration Gravity down flow
Surface loading (m/d)	:	120 - 150
Filter media		
type	:	Single media
depth (cm)	:	60 - 70
effective size (mm)	:	0.45 - 0.70
Underdrain		
gravel layer	:	100- 150 mm x 4 layers
underdrain type	:	Bored pipe
Surface washing		
type	:	fixed nozzle
jet pressure(kg/cm2)	:	1.5 - 2.0
washing time (min)	:	4 - 6
rate (m3/m2/min)	:	0.2
Backwashing		
rate (m3/m2/min)	:	0.6 or larger
washing time (min)	:	5 - 10

f. Clear Water Reservoir

Retention time (hour)	:	8.0
Depth (m)	:	3 - 6

g. Chemical feeding

Alum		
coagulant	:	Solid aluminum sulfate
mixing	:	Batch mixing
dosage rate	:	5 - 10
Lime (as necessarily)		
objective	:	pH control for coagulation
chemical type	:	Slaked lime (Ca(OH)2)

h. Chlorination

Chemical type	:	Chlorine gas

Minimum storage	:	1 month
Type of injector	:	Vacuum type injector
Dosage rate (ppm)	:	2.0

i. Instrumentation

General concept

Centralized operation not to be introduced;

Operation to be manual control

Flows to be measured	:	Raw and treated water
Levels to be measured	:	Clear water reservoir
Weights to be measured	:	Chlorine gas cylinder
Head to be measured	:	Filter loss

(4) Distribution Facilities

a. Service pressure

Minimum pressure (kg/cm2): 1.0 (for hourly maximum flow)

6. BASIS OF COST ESTIMATES

6.1 Construction Cost

(1) General

Construction cost of facilities to be built is calculated with prices in 1989 on the basis of the various unit costs.

The construction cost is calculated by different items in the manner as described below:

a. Pipelines : by linear meter for
- o Transmission pipes
- o Distribution pipes

b. Water Treatment Plant : by facilities for
- o Receiving well
- o Sedimentation basin
- o Sand filter
- o Clear water reservoir
- o Elevated tank
- o Pumping house
- o Chemical house
- o Mechanical works
- o Electrical works
- o Miscellaneous

c. Land Acquisition

These costs are separated in Foreign and Local Cost portion with the percentage by item as shown below:

Work Item	Foreign Currency	Local Currency
Pipeline	(%)	(%)
A/C pipes	30	70
Steel pipes	80	20
Structural/Architectural	30	70
Mechanical Works	80	20
Electrical Works	80	20
Land Acquisition	0	100

(2) Pipeline Construction

Pipelines are firstly separated into two major groups: (i) transmission pipeline for either raw water or clear water, but not for distribution, and (ii) distribution pipeline.

Unit costs for construction of transmission pipeline are calculated by linear meter, consisting of the material, transportation (two cases as more than 800 km, or smaller) and installation costs. Cost for fittings are assumed as 10 and 15 percent of pipe material cost for asbestos cement and steel pipes, respectively. These ratios are set smaller compared to that of the distribution pipes because of the simplicity in the pipeline components.

Unit costs of distribution pipeline are calculated in the same manner as that for the transmission pipeline. The ratios for fittings are set as 25 and 35 percent of the pipe material cost for asbestos cement and steel pipes, respectively.

(3) Treatment Plant

Cost for the treatment plant is calculated by the unit cost by facility of plant component of various capacity which has been used by PWA for planning purpose. Each cost is updated to meet the increased construction cost in 1989.

Unit costs for facilities, which are not included in the PWA's unit cost list, are calculated assuming the unit costs for the major items as follows:

- o Concrete works by concrete volume, including related works as reinforcement (assuming 100 kg/cu m of concrete), forming, scaffolding, supporting.
- o Earth works by soil volume for excavation and fill
- o Architectural works by unit area of building
- o Concrete piles by each pile, including material, transportation and driving cost

(4) Mechanical Works

Costs for the plant facilities included in the mechanical works are calculated on the basis of the number of unit of each equipment such as pump, flocculator, sludge remover, or chemical and chlorination dosage equipment. Additional percentage is assumed for the miscellaneous items as pipings and fittings.

(5) Electrical Works

Cost for the electrical works substantially varies depending on the instrumentation system. The records in the construction of the advanced water supply system shows it would share as much as 40 percent of the total construction cost if the sophisticated computer control system is employed. Employing the more simple system could reduce this cost much.

The system to be recommended in this study should be the simple one as described in the Design Criteria so that the cost for the system could be lowered. It is practical and common way to assume that the cost of the electrical works closely related to the cost of the mechanical works. In this study, the cost is therefore, calculated by percentage of the mechanical works.

The details of the unit cost are shown in the Appendix A-6-1.

6.2 Operation and Maintenance Cost

(1) General

Operation and maintenance cost is calculated on the basis of the price and rate in 1989, and consists of the following factors:

- o Energy Cost
- o Chemical Cost
- o Manning Cost
- o Repair Cost
- o Replacement

This cost is calculated in local currency only.

(2) Energy Cost

It is practical that the energy for the operation will be provided in the form of the electricity by Provincial Electricity Authority (PEA).

The Energy cost is calculated separately for the demand charge and energy charge with the PEA rate in 1989 which are:

Demand Charge : Baht 229 /KW/month

Energy Charge : Baht 1.23 /KWH

(3) Chemical Cost

Unit chemical costs are as follows:

Alum : Baht 3.9 /kg

Lime : Baht 1.25 /kg

Chlorine Gas : Baht 15.6 /kg (excluding gas container)

(4) Manning Cost

The unit manning costs of each year are calculated from the average manning cost in 1987, which is Baht 7,703 per person per month. The annual increment of the monthly salary is set to be 5 percent.

(5) Repair Cost

Repair cost should be counted for repairing and maintaining the plant equipment. This cost is calculated as 0.3 percent of the construction cost of the mechanical and electrical works.

(6) Replacement

Each facility to be constructed should have a certain life time. The span for the life time is varying depending on its nature of the facility. The followings are the life time of the facilities to be taken in this study and concept for replacement:

Item	Life time span	To be replaced after life time
Pipeline		
A/C pipes	20 years	50 percent
Steel Pipes	30	50
Concrete Structures		
Treatment Plant	50	100
Reservoir	50	100
Mechanical Equipment	20	100
Electrical System	20	50

(7) Cost of the Head and Regional Office

Cost of the PWA's head office and the regional office are allocated and added, in the financial study in Chapter 17, to the direct operation costs above. The allocation is determined assuming the future increment of their costs in each office, detailes of which is explained in Chapter 13.

Part 2
DEVELOPMENT PLAN

Part 2 DEVELOPMENT PLAN

7. CONSIDERATION FOR DEVELOPMENT PLAN

Expansion of the treatment plant capacity and verification for the transmission pipe for Na Bon are the two main subjects in consideration for the development plan.

The treatment plant capacity should be increased to produce the planned amount of water demand in 2011. Expansion of facilities is required although the improvement plan is prepared by PWA in the same manner as implemented at the Thung Song Waterworks in 1987. Construction of new facilities may require the land acquisition since the existing plant does not have enough space for expansion therein.

A new transmission pipe for Na Bon is proposed and has been designed by PWA since the existing pipe can not bear the high pressure which is required to convey treated water from Thung Song Waterworks to Na Bon. As the existing pipe is of asbestos cement (class 15) and time- worn, transmitting pressure (maximum about 3.8 kg/sq cm) causes leaking and burst. The waterworks is therefore sending water with low pressure; consequently, amount of water transmitted is not sufficient.

PWA has prepared a detailed design of the new water transmission pipeline. The new pipe is to be connected to the existing pipe at about 5 km before Na Bon.

Expansion of the distribution network will be planned according to the planned extent of the future service area. Improvement in the existing network is also discussed.

8. DEFINITION AND EVALUATION OF ALTERNATIVES

8.1 Water Source

8.1.1 Comparative Study

As previously mentioned in Chapter 2, several alternatives can be considered. The comparative study was made as shown in Table 8-1-1.

Table 8-1-1 Evaluation of Alternatives

Alternative	Water Supply Capacity	Constr'n Difficulty	Tech'l Problem	Constr'n Cost	Social & Political
Concrete Weir	Good	Fair	Fair	Good	Good
Divers'n	Good	Fair	Fair	Fair	Fair
Dam	Good	Poor	Poor	Poor	Poor
Ground Water	Fair	Poor	Poor	Fair	Fair

Since the intake point in the khlong Nam Tok Young has a sufficient flow throgh a year and good quality for water supply, facilities required are concrete intake dam in order to secure stable intake by raising the water level.

For temporary, by the completion of the intake dam a number of concrete blocks or stones should be placed on the existing intake point in order to raise the intake water level.

8.1.2 Design Criteria

(1) Intake Water Level

Suction Water Level : EL. +95.50

Intake Water Level

Screen Loss

$$h_1 = 1.79 \times \sin 90^{o} \times (0.01/0.05)^{(4/3)} \times (0.8^2/2 \times 9.8$$
$$= 0.007 \text{ m}$$

Intake Loss

$$h_2 = 2.0 \times (0.8^2/2 \times 9.8)$$
$$= 0.065 \text{ m}$$

Friction Loss

$$h_3 = (1/2) \times (n^2 \times V^2/R^{(4/3)}) \times l$$
$$= 0.078 \text{ m}$$

where, n : friction loss (=0.015)
R : hydraulic radius (=0.167 m)
V : velocity (=0.8 m/s)
1 : canal length (=100 m)

Total Loss

$h = h_1+h_2+h_3$
$= 0.15$ m

Intake Water Level = H.W.L.+h
= EL+95.65 m < EL+96.50 m

(2) Intake Velocity

0.8 m/s

(3) Intake Canal

Bottom Elevation = River Bed Elevation+1.0
= 95.0+1.0
= EL+96.00 m

Height $B = q/h_1 xV$
$= 0.475$
= 0.5 m

where, Q : intake amount (= 0.19 cu.m/s)
V : intake velocity (= 0.8 m/s)
h_1 : intake depth (= 0.50 m)

(4) High Water Level

According to the hydrological analysis made by tank model, the daily maximum flow is shown in table 8-1-2.

The maximum flow in once in ten years is estimated at 28.6 cu.m/s. Therefore, the high water level is obtained from the following equation:

$Q=AxV$

$V=R^{(2/3)}xI^{(1/2)}/n$
=29.0 cu.m/s

where, I=(94.681-94.299)/100=0.004
n=0.100 (in the natural stream)
R=2.5(=H)

High Water Level=95.0+2.5=EL+97.50 m

Table 8-1-2 Maximum Flow at Intake Point
(Unit : cu.m/s)

Year	Date	Maximum Flow
1978	10.19	7.715
1979	11.20	11.494
1980	11.30	19.624
1981	12.30	19.921
1982	11.20	11.911
1983	12.14	6.108
1984	11.29	28.596
1985	11.40	6.914
1986	9.70	9.975
1987	12.60	23.961

8.1.3 Water Source Development Plan

As previously descrived in Chapter 2, the Khlong Nam Tok Yong has sufficient streamflow all year round to meet the daily maximum water demand in 2011.

However, for the purpose of securing the stable intake and draining deposited sediment during the flood season, a fixed concrete weir with a gate should be constructed by 1993. In the meantime, stone brocks or concrete brocks should be temporarily placed at the present intake point to raise the intake water level.

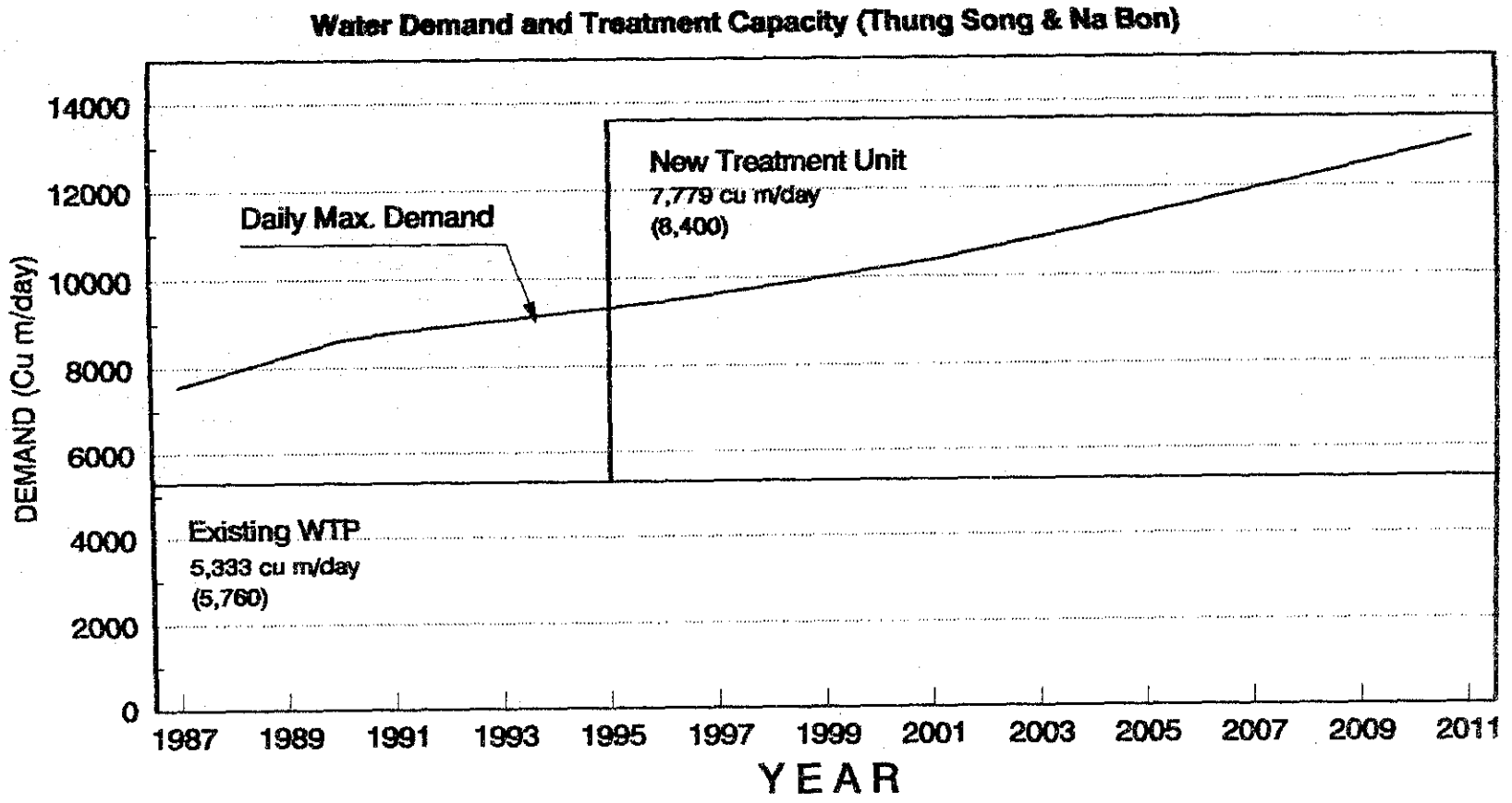
8.2 Water Supply System

8.2.1 Water Treatment Plant

PWA has implemented a modification of the existing water treatment plant to increase its treatment capacity from 160 cu m/h (3,840 cu m/d) up to 240 cu m/h (5,760 cu m/d). The existing capacity of the plant is however lower than the planned daily maximum water demand in 1991 which is 8,480 cu m/d. Therefore, immediate measures for increasing a treatment capacity should be taken to meet the demand and to augment the water supply service.

A new treatment plant facility should be constructed to meet this requirement. The total of additional treatment capacity for 2011 is about 8,000 cu m/d so that total plant capacity will be 12,760 cu m/d which will be able to cover the planned daily maximum water demand in 2011, 13,110 cu m/d. Figure 8.2.1 shows an implementing plan for the treatment plant development with a treatment capacity.

The expansion of the treatment plant at the existing plant site is recommended since existing raw water source is sufficient in its supply capacity and the existing raw water intake will be used through the future. Figure 8.2.2 shows a proposed expansion plan at the existing plant site.



Water Treatment Plant Capacity

7,779 cu m/day : Net Treatment Capacity

(8,400) : Design Capacity (incl.Treatment loss)

FIGURE 8-2-1
Water Treatment Plant
Construction Plan

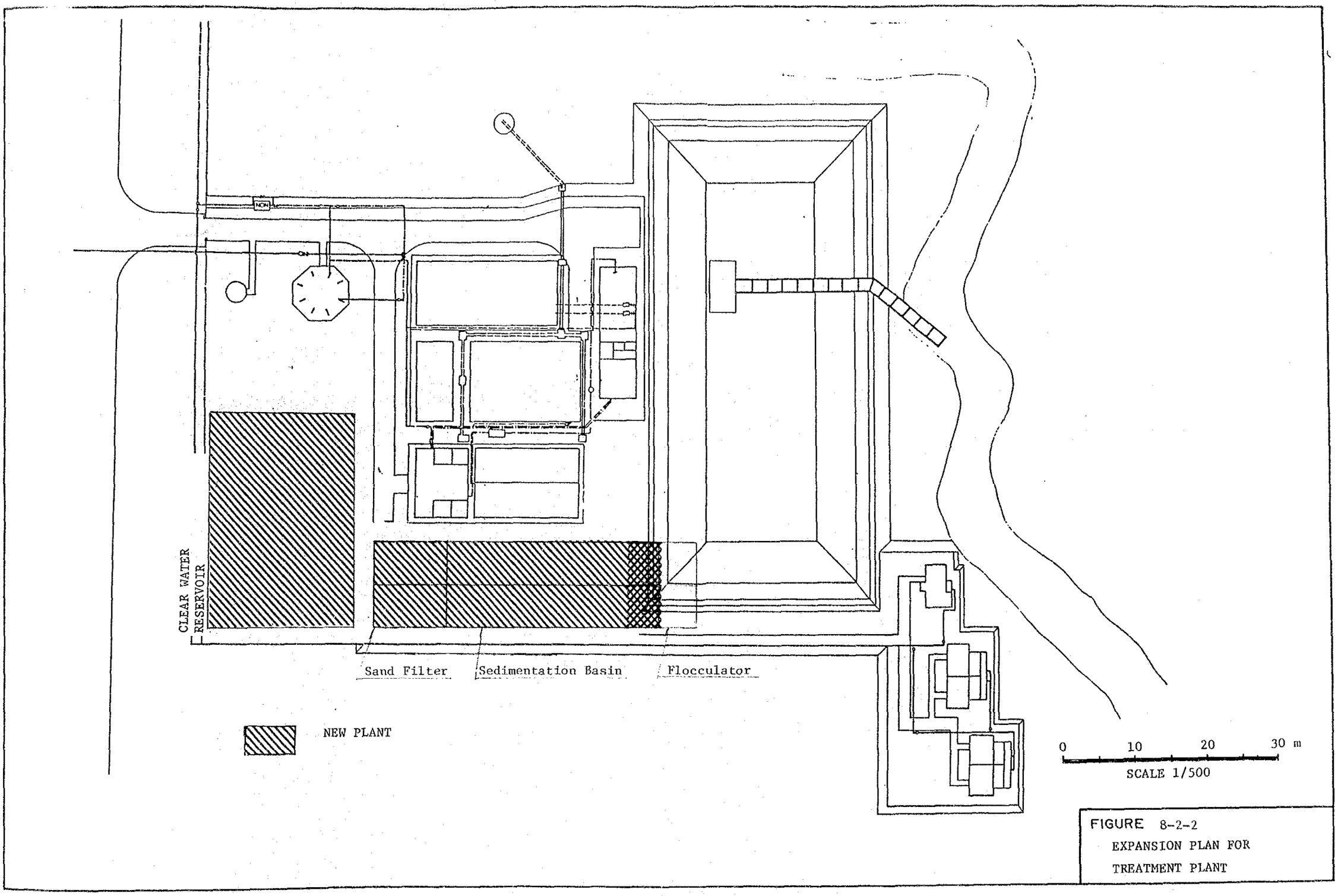


FIGURE 8-2-2
EXPANSION PLAN FOR
TREATMENT PLANT

8.2.2 Water Transmission Pipeline for Na Bon

(a) Transmission capacity of the existing pipe

Existing water transmission pipe for Na Bon is of asbestos cement (class 15) with a diameter of 150 mm. Figure 8.2.3 shows the right of way of the existing and proposed transmission pipeline. Since this pipe is old and of lower standard in classification of pressure, it is not used with a maximum pumping head at a treatment plant which is about 40 meters. Water is transmitted with a pressure of less than 10 meters at a plant. Therefore, sufficient water is not presently conveyed to Na Bon.

Maximum transmission capacity of this pipe is calculated to be 540 cu m/d as shown in Figure 8.2.4, even assuming that pipe is durable against the pumping head of 40 meters at the plant. This amount is apparently lower than the predicted daily average water demand in Na Bon in 1990, which is 748 cu m/d.

(b) Transmission capacity of the pipe designed by PWA

PWA has prepared a detailed design for a new water transmission pipeline with a diameter of 150 mm and class 20 to cope with a pumping head at the plant. With these characteristics and topographic profile, maximum transmission capacity was calculated to be 590 cu m/d as shown in Figure 8.2.5.

However, this amount is still less than a planned daily maximum demand predicted even for 1990.

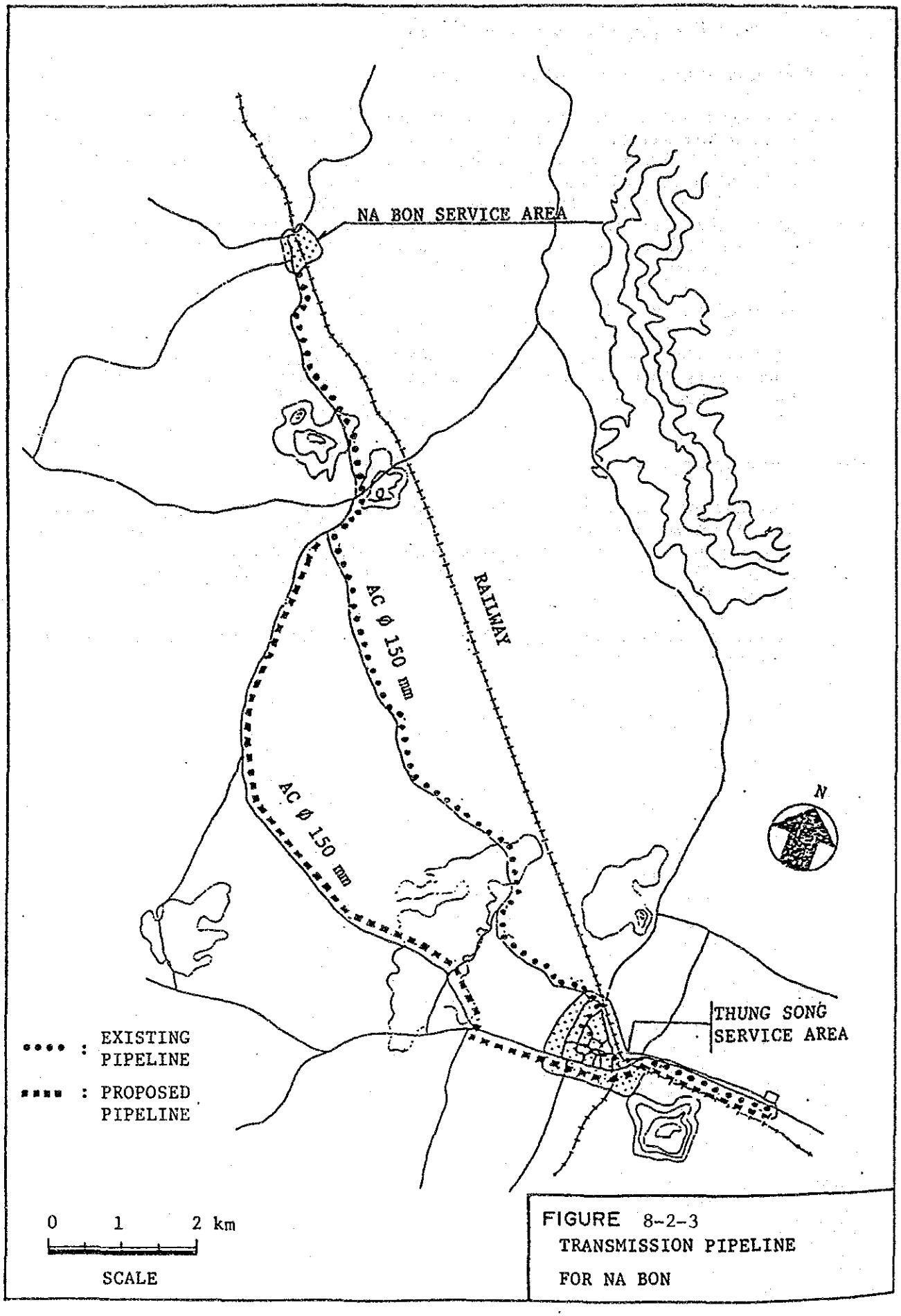


FIGURE 8-2-3
TRANSMISSION PIPELINE
FOR NA BON

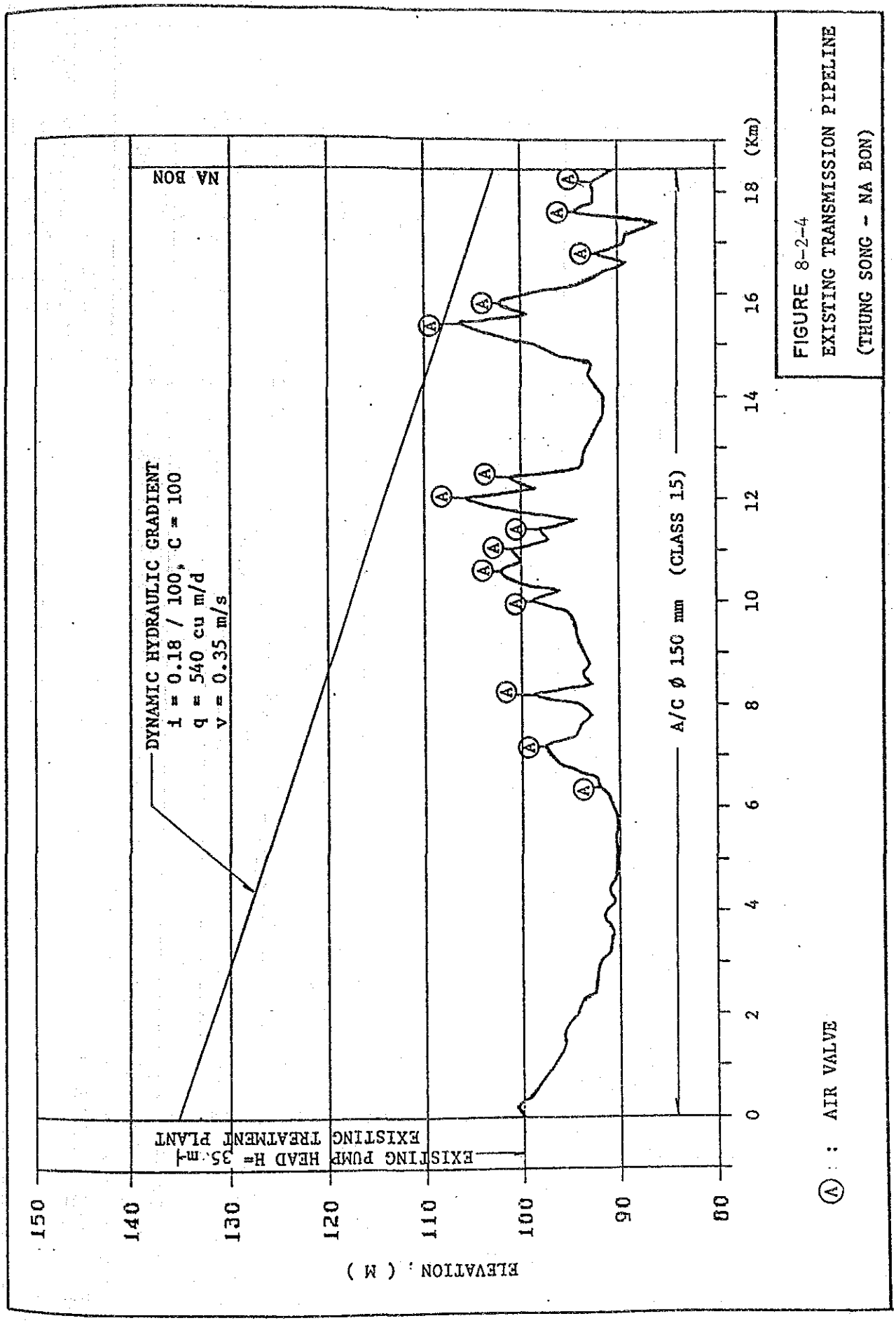


FIGURE 8-2-4
EXISTING TRANSMISSION PIPELINE
(THUNG SONG - NA BON)

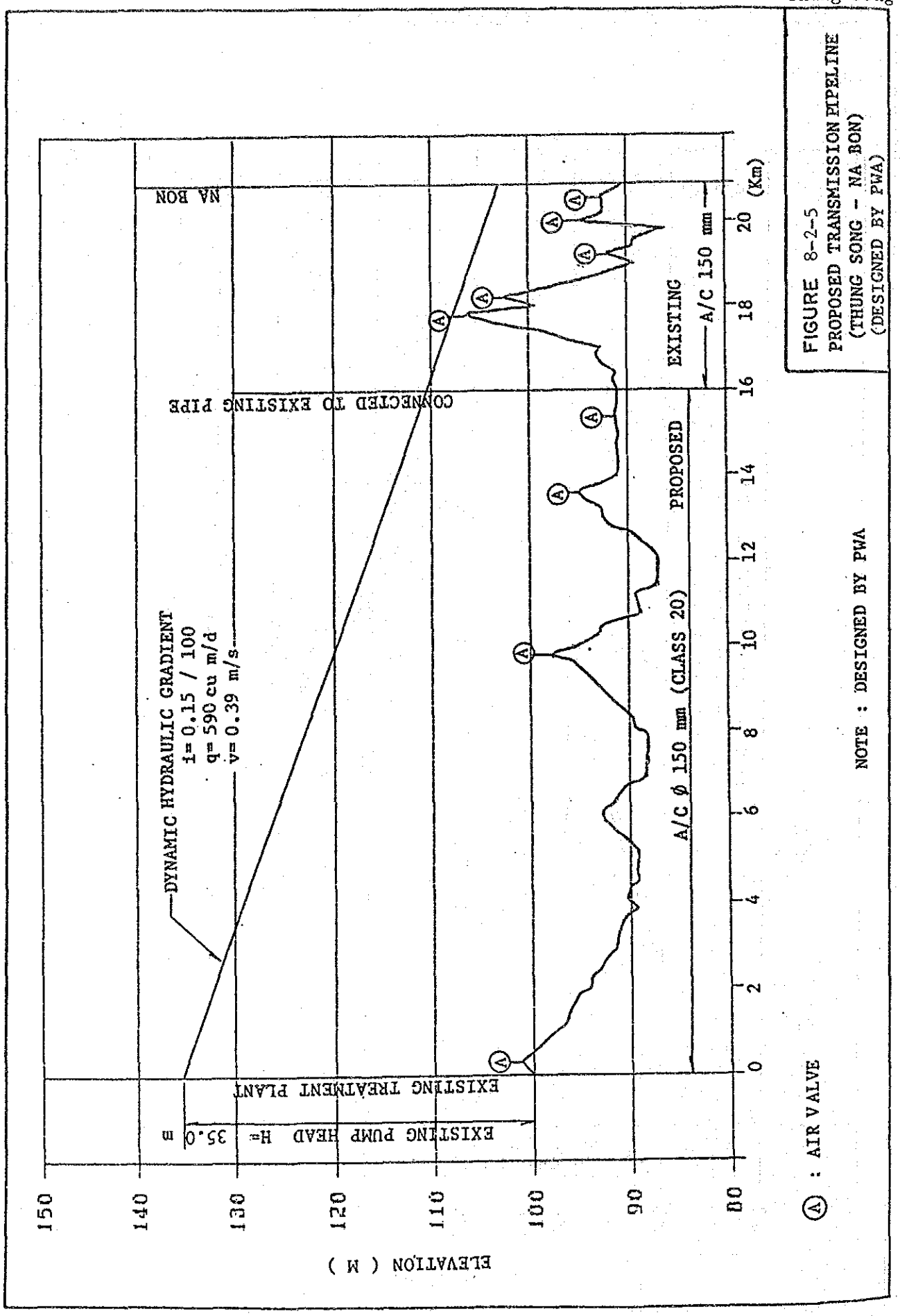


FIGURE 8-2-5
PROPOSED TRANSMISSION PIPELINE
(THUNG SONG - NA BON)
(DESIGNED BY PWA)

(c) Recommended scheme for water transmission pipeline

As the present design is not sufficient in capacity to meet a planned water demand in 1990, increase of the transmission capacity is inevitable. To achieve this, an additional pipeline should be installed as recommeded below:

Diameter	: 200 mm
Material	: AC
Maximum flow	: 1,150 cu m/day
Transmission Head	: 35 m

It is assumed that this additional pipeline will be constructed in 1994 as well as the new treatment plant.

8.2.3 Distribution Pipeline

The distribution system with a water demand in 2011 was analyzed to optimize the system. The minimum pressure in the hourly maximum flow is set at 1.0kg/sq.cm for general application, except for high ground elevation area and rural area where 0.4 to 0.5 kg/sq.cm may be tolerated.

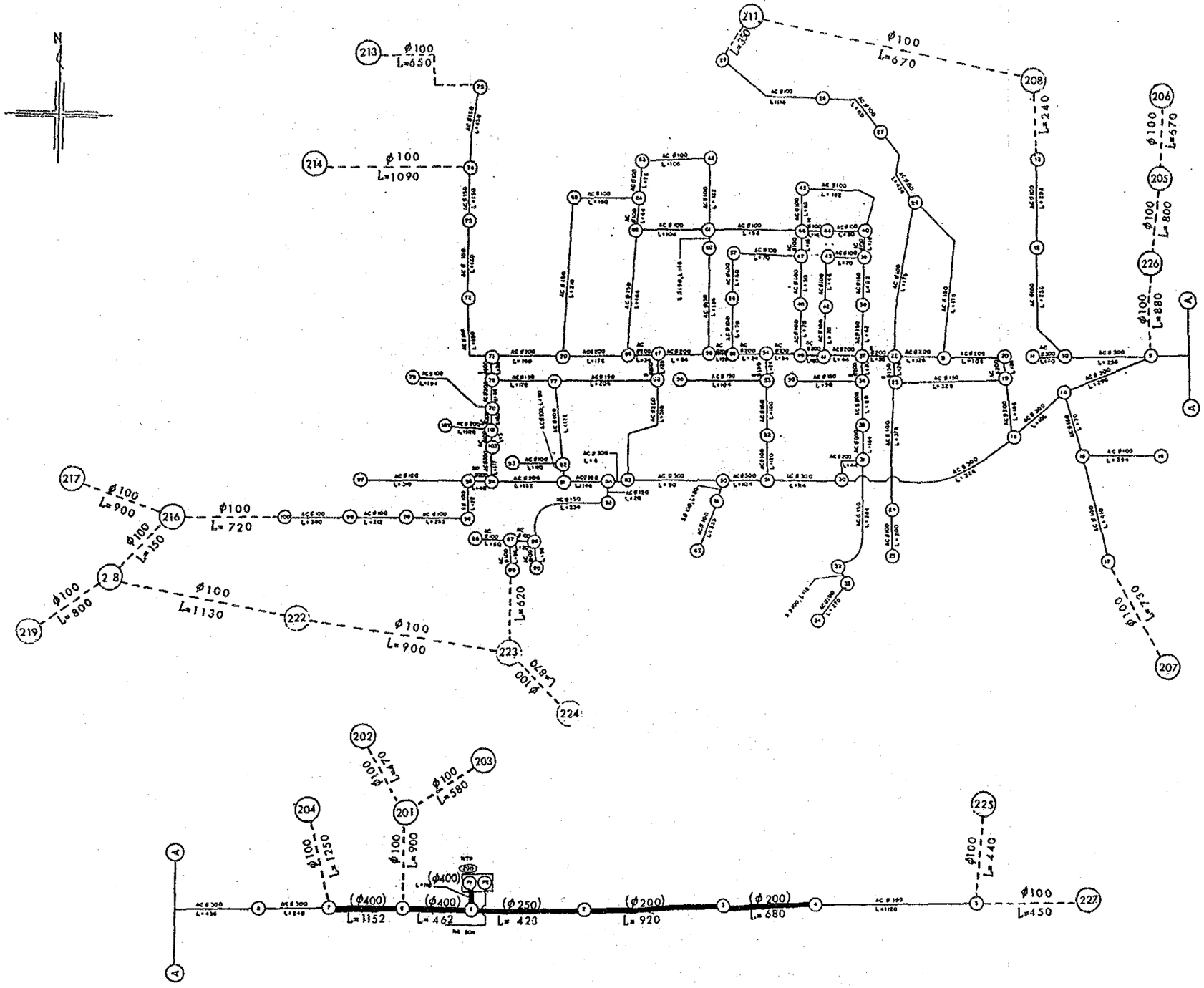
Based on the results of the distribution network analysis, pipeline are planned to serve the maximum hourly flows with sufficient service pressure throughout the proposed system. The proposed system for Thung Song consist of the installation of 15.7km long mains of 100 mm diameter.

A schematic plan for the proposed network system is shown in Figure 8.2.6. The result of the distribution network analysis is presented in Appendix A-8-2. For Na Bon, it is recommended that transmission pipeline from Thung Song Waterworks should be directly connected to the existing receiving tank.

Replacement of a part of the existing pipe is also recommended for Thung Song municipality. However, Na Bon area needs no replacement of the existing pipe. Breakdown of the proposed distribution pipeline including the replacement of the existing pipeline system are tabalated in Table 8-2-1.

Table 8-2-1 Proposed Distribution Pipelins

Dia (mm)	Length (m)	Material
1) Replacement		
(Thung Song)		
350	1730	AC
250	430	AC
200	1600	AC
(Na Bon)		
None	-	-
2) Proposed		
(Thung Song)		
100	15,700	AC
(Na Bon)		
None	-	-



LEGEND

①	Node Number for Existing Pipeline
(211)	Node Number for Existing Pipeline
φ100 L=500	Proposed Pipeline and its Diameter & Length (mm) (m)
(φ150)	← Proposed Diameter (mm)
φ100 ①—② L=500 (L= 450)	Replacement of Existing Pipeline ← Proposed Length (m) if necessary, otherwise same as the existing one.
φ200 L=250	Existing Pipeline and its Diameter & Length (mm) (m)

FIGURE 8-2-6

PROPOSED DISTRIBUTION PIPELINE (Thung Song)

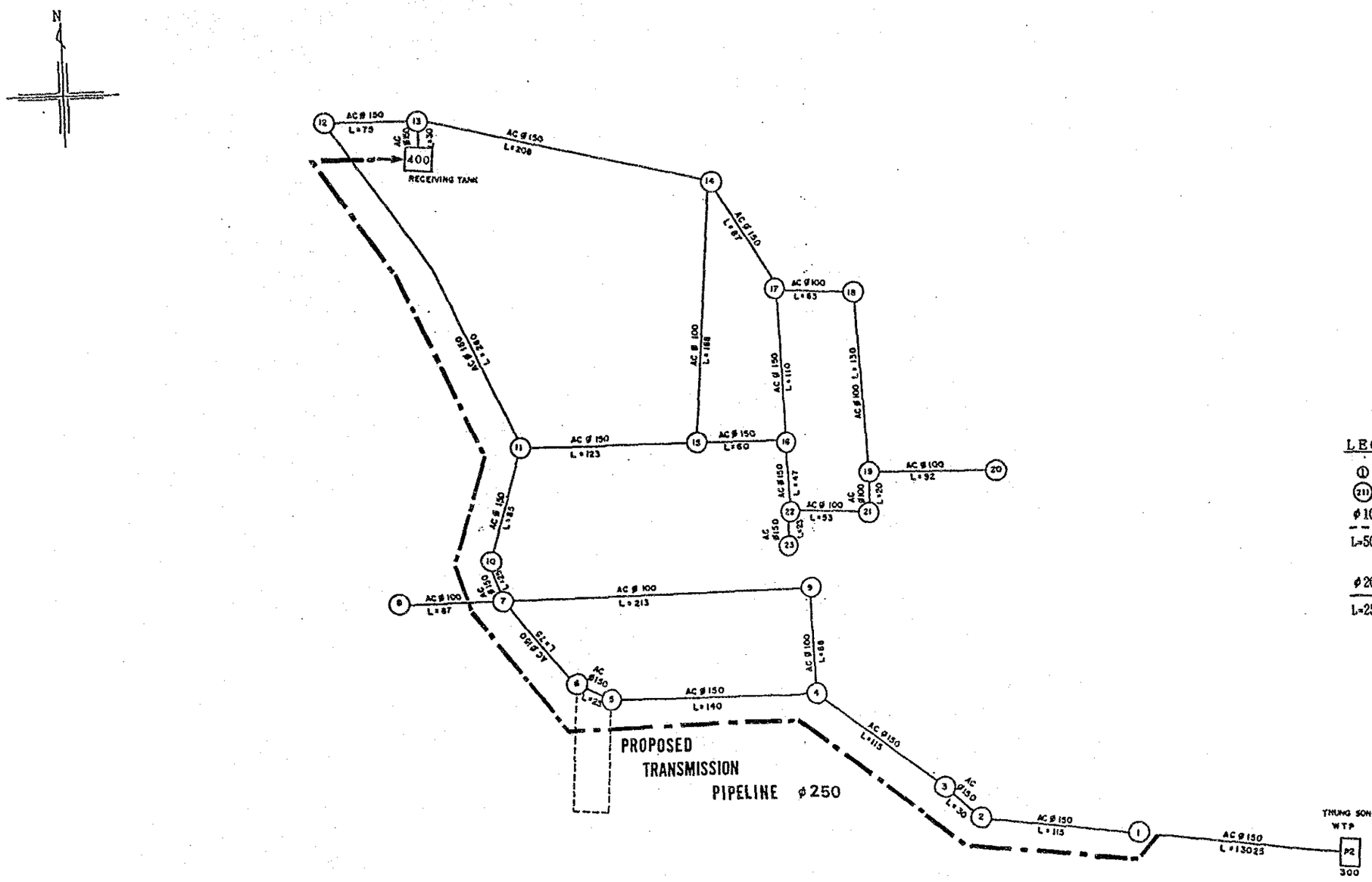


FIGURE 8-2-6(Cont'd)
PROPOSED DISTRIBUTION PIPELINE
(No Bon)

9. IMPLEMENTATION PLAN

The implementation plan of the total project is proposed as shown in Figure 9-1. In this program, the facility construction is prepared following the water demand prediction. The construction of the treatment plant will be carried out in one phase. It is assumed that the distribution pipelines will be constructed in two years.

Amount (Cu m/day)
14000
12000
10000
8000
6000
4000
2000
0
Daily Max. Demand
New Treatment Unit
7,779 cu m/day
(8,400)
Existing WTP
5,333 cu m/day
(5,760)
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
Raw Water Intake
New Treatment Plant
Tr. Pipe for Na Bon
Distribution Pipeline
Construction
Operation
Water Treatment Plant Capacity
7,779 cu m/day : Net Treatment Capacity
(8,400) : Design Capacity (incl.Treatment loss)
FIGURE 9-1
Implementation Plan

10. ORGANIZATION OF WATERWORKS

The organization of the waterworks is proposed with consideration on the components and size of the proposed water supply system. The construction of sections is based on the existing organization chart of the waterworks. The proposed organization consists of the administration, water production, and service sections as shown in Figure 10-1.

The major tasks of each section are described as follows:

(1) Administration Section

This section will be responsible for the administrative and financial issues of the waterworks. The works to be done will include the preparation of the general administration for the waterworks' staff, meter reading and preparation of bills, collectin of water charge, and management of the documents and records.

(2) Water Production Section

This section will be responsible for the operation and maintenance of the water treatment plants and the raw water intake. Inspection of the transmission pipelines will be performed by this section.

(3) Service Section

This section will be responsible for setting and repair of house connection.

Numbers of staff of each section are decided from the water demand in each year. Ratios of present number of staff and the water demand in 1987 are used in calculating the future number of staff.

Table 10-1 shows numbers of staff.

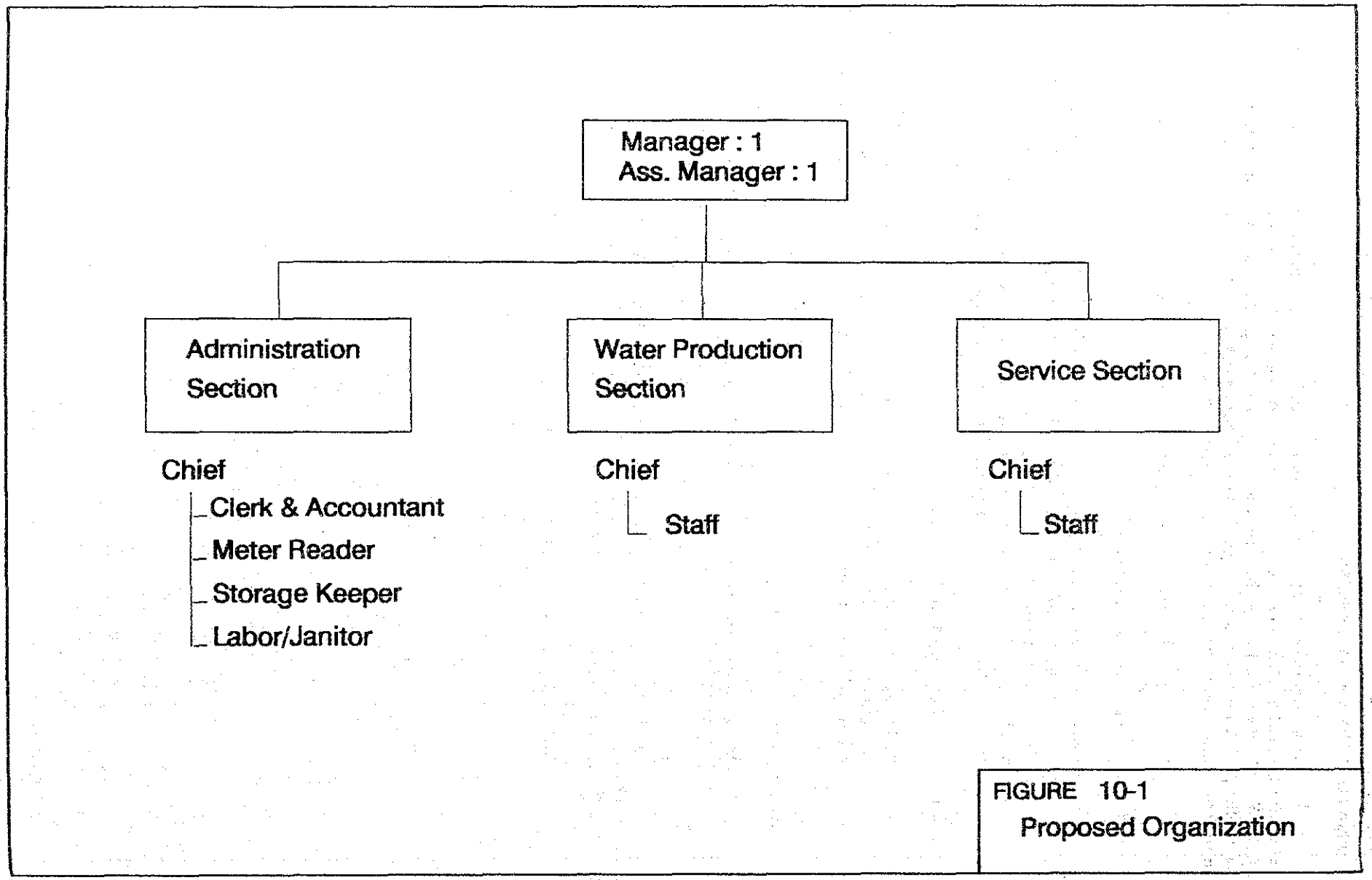


FIGURE 10-1
Proposed Organization

Table 10 - 1 Proposed No. of Staff

Year	No. of Staff	Manager	Administrative					Water Production		Service Section	
	Total		Chief	Clerk Account	Storage Keeper	Meter Reader	Labor etc.	Chief	Staff	Chief	Staff
1990	24	1	1	4	0	4	1	1	5	1	6
1991	24	1	1	4	0	4	1	1	5	1	6
1992	24	1	1	4	0	4	1	1	5	1	6
1993	24	1	1	4	0	4	1	1	5	1	6
1994	24	1	1	4	0	4	1	1	5	1	6
1995	24	1	1	4	0	4	1	1	5	1	6
1996	25	1	1	4	0	4	1	1	5	1	7
1997	26	1	1	4	0	4	1	1	6	1	7
1998	28	1	1	5	0	5	1	1	6	1	7
1999	28	1	1	5	0	5	1	1	6	1	7
2000	28	1	1	5	0	5	1	1	6	1	7
2001	28	1	1	5	0	5	1	1	6	1	7
2002	28	1	1	5	0	5	1	1	6	1	7
2003	29	1	1	5	0	5	1	1	6	1	8
2004	29	1	1	5	0	5	1	1	6	1	8
2005	30	1	1	5	0	5	1	1	7	1	8
2006	30	1	1	5	0	5	1	1	7	1	8
2007	32	1	1	6	0	6	1	1	7	1	8
2008	33	1	1	6	0	6	1	1	7	1	9
2009	33	1	1	6	0	6	1	1	7	1	9
2010	33	1	1	6	0	6	1	1	7	1	9
2011	34	1	1	6	0	6	1	1	8	1	9

11. PROJECT COST ESTIMATES

11.1 Construction Cost

The construction cost of the water supply system was calculated for each component of facility. Table 11-1 shows a summary of the construction cost based on the 1989 price.

Table 11-1 Summary of the Construction Cost

(unit : Baht 1000)

Item	Total Value	Foreign Currency Portion	Local Currency Portion
1.Raw Water Intake	1,954	586	1,368
2.Treatment Plant	28,609	10,952	17,657
3.Transmission Pipeline for Na Bon	15,170	4,551	10,619
4.Distribution Pipeline	11,642	3,493	8,149
Sub Total	57,375	19,582	37,793
5.Land Cost	0	0	0
Total	57,375	19,582	37,793

The breakdown of the cost estimates are shown in Tables 11-2 to 7.

Table 11-2 Cost Breakdown of the Raw Water Intake Facility

(unit : Baht 1000)

Item	Total Value	Foreign Currency Portion	Local Currency Portion
A. Earth Work	157	47	110
B. Structural Work	1,620	486	1,134
C. Miscellaneous	178	53	124
Total	1,954	586	1,368

Table 11-3 Cost Breakdown of the Treatment Plant
(unit : Baht 1000)

Item	Total Value	Foreign Currency Portion	Local Currency Portion
A. Civil/Architectural Works			
1. Receiving Well	12	4	8
2. Sedimentation Basin	8,050	2,415	5,635
3. Rapid Sand Filter	4,200	1,260	2,940
4. Clear Water Reservoir	8,700	2,610	6,090
5. Pumping House	360	108	252
6. Chemical House	380	114	266
Sub-total of A.	21,702	6,511	15,191
B. Mechanical Works			
1. Clear Water Pump 200mm, 4 units	1,400	1,120	280
2. Chemical Equipment	640	512	128
3. Chlorination Equip	720	576	144
4. Others (20% of above)	552	442	110
Sub-total of B.	3,312	2,650	662
C. Electrical Works (30 % of Mechanical)	994	795	199
D. Miscellaneous(10%ofA,B,C)	2,601	996	1,605
Total	28,609	10,952	17,657

Table 11-4 Cost Breakdown of the Transmission Pipeline for Na Bon
(unit : Baht 1000)

Pipeline From	To	Dia(mm)	L (m)	Total Value	Foreign Currency Portion	Local Currency Portion
WTP	Na Bon	200	18,500	15,170	4,551	10,619
Total				15,170	4,551	10,619

Table 11-5 Cost Breakdown of the Distribution Pipeline
(unit :Baht 1000)

Pipe Dia(mm)	L (m)	Material	Total Value	Foreign Currency Portion	Local Currency Portion
(Replacement)					
200	1,600	AC	1,424	427	997
250	430	AC	507	152	355
300	1,730	AC	2,803	841	1,962
Sub-Total	3,760		4,734	1,420	3,314
(New Construction)					
100	15,700	AC	6,908	2,072	4,836
Sub-Total	15,700		6,900	2,072	4,836
Total			11,642	3,493	8,149

11.2 Operation and Maintenance Cost

It is assumed that the new treatment unit with a treatment capacity of 3,300 cu m/day will start operation in 1994.

Operation and maintenance cost is calculated from the water demand in each year, and consists of energy, chemical, manning, repair, and replacement costs.

Manning cost is based on the prediction of the staff number of waterworks as proposed in Chapter 10.

Replacement of the mechanical and electrical equipment is considered to be made 20 years after the installation so that they are not included in the period of the development plan.

Total operation and maintenance cost is tabulated in Table 11-6.

Table 11-6 Summary of Operation and Maintenance Cost
(unit : Baht 1000)

Year	Energy Cost	Chemical Cost	Manning Cost	Repair Cost	Replace-ment	Total
1990	975	131	2,446			3,552
1991	982	135	2,568			3,685
1992	987	137	2,697			3,821
1993	993	140	2,831			3,964
1994	999	142	2,973			4,114
1995	1,000	145	3,122			4,266
1996	1,014	147	3,414	25		4,601
1997	1,028	150	3,728	25		4,932
1998	1,042	153	4,216	25		5,436
1999	1,137	156	4,427	25		5,745
2000	1,208	159	4,648	25		6,040
2001	1,224	162	4,880	25		6,292
2002	1,245	166	5,124	25		6,561
2003	1,266	171	5,573	25		7,035
2004	1,288	175	5,852	25		7,340
2005	1,310	180	6,356	25		7,871
2006	1,332	184	6,674	25		8,215
2007	1,356	189	7,475	25		9,045
2008	1,381	194	8,094	25		9,694
2009	1,405	199	8,498	25		10,128
2010	1,507	204	8,923	25		10,660
2011	1,534	210	9,653	25		11,422

12. ANNUAL DISBURSEMENT SCHEDULE

The annual disbursement schedule is prepared on the basis of the construction schedule and the cost estimates as shown in the Chapter 9, and 10, respectively.

Table 12-1 shows an annual disbursement by item.

Table 12-1 Annual Disbursement Schedule

(Unit : Baht 1000)

Year	CONSTRUCTION COST						Engineering Cost			Operation: Cost	Land Cost	Grand Total
	Intake	WTP	Trans. Pipe	Distrib. Pipe	Contin-gency	Sub-Total	Design	Super-vision	Sub-Total			
Total	1,954	28,609	15,170	11,642	5,738	63,113	5,049	2,525	7,574	144,416	0	215,102
1990	0	0	0	0	0	0	0	0	0	3,552	0	3,552
1991	0	0	0	0	0	0	0	0	0	3,685	0	3,685
1992	0	0	0	0	0	0	1,010	0	1,010	3,821	0	4,830
1993	0	0	0	5,821	582	6,403	4,039	0	4,039	3,964	0	14,406
1994	1,954	28,609	15,170	5,821	5,155	56,709	0	2,525	2,525	4,114	0	63,348
1995	0	0	0	0	0	0	0	0	0	4,266	0	4,266
1996	0	0	0	0	0	0	0	0	0	4,601	0	4,601
1997	0	0	0	0	0	0	0	0	0	4,932	0	4,932
1998	0	0	0	0	0	0	0	0	0	5,436	0	5,436
1999	0	0	0	0	0	0	0	0	0	5,745	0	5,745
2000	0	0	0	0	0	0	0	0	0	6,040	0	6,040
2001	0	0	0	0	0	0	0	0	0	6,292	0	6,292
2002	0	0	0	0	0	0	0	0	0	6,561	0	6,561
2003	0	0	0	0	0	0	0	0	0	7,035	0	7,035
2004	0	0	0	0	0	0	0	0	0	7,340	0	7,340
2005	0	0	0	0	0	0	0	0	0	7,871	0	7,871
2006	0	0	0	0	0	0	0	0	0	8,215	0	8,215
2007	0	0	0	0	0	0	0	0	0	9,045	0	9,045
2008	0	0	0	0	0	0	0	0	0	9,694	0	9,694
2009	0	0	0	0	0	0	0	0	0	10,128	0	10,128
2010	0	0	0	0	0	0	0	0	0	10,660	0	10,660
2011	0	0	0	0	0	0	0	0	0	11,422	0	11,422

Note: 1. Contingency = 10 % of the total of gross construction cost

2. Engineering Cost (Design) = 8 % of the total construction cost

3. Engineering Cost (Supervision) = 4 % of the total construction cost

13. FINANCIAL STUDY

The financial plan for the proposed water supply system is studied to enable the waterworks to take necessary steps for the viable implementation of the project with due consideration on the existing financial practices, potential finding sources to meet the estimated capital costs for the construction and recurrent costs for the operation.

13.1 Funding Arrangements

The funds are required largely in two categories for the construction capital and recurrent costs for yearly operating and maintenance of the systems, including debt service, depreciation and other miscellaneous expenses.

1) Cost Estimates

The required costs break down and the implementation-disbursement schedule into annual disbursement for the construction stage are presented in Table 13-1-1.

2) Funds for Construction Costs

Out of the total capital costs, the foreign currency portion is financed by the international lending agency which the local currency portion is financed by the government subsidies, PWA's own equity or loan.

Such international loans are normally provided to finance the foreign currency portion of the project costs; however, in certain cases, a part of local currency portion is also financed by international loan when such is desirable.

If the funding capability of the executing agency is not sufficient, the subsidy from the central government to the possible extent may be desirable and more soft loans with low interest and longer period of repayment should be sought.

Table 13-1-1 Implementation/Disbursement Schedule

(Unit : Baht x 1000)

Year	Construction Cost			Engineering Cost						Sub-Total			Contingency			Grand Total		
				Design			Supervision											
	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
Total	19,583	37,792	57,375	1,724	3,325	5,049	862	1,663	2,525	22,169	42,780	64,949	1,959	3,779	5,738	24,128	46,559	70,687
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1992	0	0	0	345	665	1,010	0	0	0	345	665	1,010	0	0	0	345	665	1,010
1993	1,747	4,074	5,821	1,379	2,660	4,039	0	0	0	3,126	6,734	9,860	175	407	582	3,301	7,141	10,442
1994	17,836	33,718	51,554	0	0	0	862	1,663	2,525	18,698	35,381	54,079	1,784	3,371	5,155	20,482	38,752	59,234
1995	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1999	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2002	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2003	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2004	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2005	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2006	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2007	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2008	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: 1.Contingency = 10 % of the total of gross construction cost

2.Engineering Cost (Design) = 8 % of the total construction cost

3.Engineering Cost (Supervision) = 4 % of the total construction cost

4.F.C.: Foreign Currency

5.L.C.: Local Currency

a. Loan from International Lending Agencies

The international loans are broadly grouped in two categories such as multilateral and bilateral loans. The multilateral loans are regarded as loans from the World Bank and Asian Development Bank. The interest of such loans are presently ranging from 6-8 percent per annum and repayment period is normally 20 years with a grace period of 5 years. The bilateral loans are exemplified by the loan from West Germany, U.S.A. or Japan with very concessionaire terms, for example, low interest rates of 2-3 percent per annum and long maturity periods (up to 30 years) including an extended grace period up to 10 years.

b. Government Subsidy

The subsidy from the central government is allocated to the local municipalities in Thailand for the construction project to develop public utilities such as irrigation and drainage system, sewerage system, feeder roads and other infrastructure development projects.

The water supply development project as proposed to enhance community benefits such as public health and economic development is necessary to be encouraged by the government initiative with allocation of meaningful amount of subsidy.

c. Loan from Domestic Banks

The local currency portion of the capital costs are normally financed by domestic banks, wholly or partly depending on availability of other sources of capital as subsidy. PWA presently borrows the fund from the Krung Thai Bank. In amortization period, PWA pays only interest part and capital repayments are in charge of the national government.

Table 13-1-2 shows loan conditions of international lending agencies.

Table 13-1-2 Loan Conditions

Agency	Interest Rate	Duration (Grace Period) Year	Charge
IBRD	7.74%	15-20 (3-5)	Front-end Fee: ——— Commitment Charge: 0.75%
IDA	0%	40 (10) or 35 (10)	Service Charge: 0.75% Commitment charge: ———
IDB	8.1%	15-25 (4-6)	Commitment Charge: 0.75% Inspection Fee 1% of loan amount
ADB	6.37%	10-30 (2-7)	Commitment Charge: 0.75%
OECF *	2.74%	28.8 (9.6)	———

* Average condition of 1988.

3) Funds for Recurrent Costs

The funds are normally required after the construction of the system to meet the annual costs including operation and maintenance costs, and debt service payment if any loan is provided. There are established practices in the developed counties that such recurrent costs are met by the users of the system who receive the benefits through the collection of water tariff.

13.2 Financing Plan

The financial plans are developed based on the capital disbursement schedule and funding arrangements. The funding arrangements are considered among others one of the most decisive factor for the financial viability of the project. The funding arrangement which will not impose unbearable burden upon the water works is most desirable subject, however, to the availability of sufficient fund or the loan of lenient condition.

In this study, the following funding plan is assumed as a recommendable funding arrangement.

Financing Plan : The total of foreign currency portion and a part of local currency portion equivalent to 9,501 thousand Baht (approximately 50 percent of the total project cost) is financed by bilateral loan and 16,640 thousand Baht is financed by equal contribution of local loan and PWA's own equity allocation.

In the financing plan, the conditions of the loan are assumed as follows.

IBRD or ADB : 20 year repayment period including 5 year grace period with 7 percent interest per annum.

Bilateral Loan : 30 year repayment period including 10 year grace period with 2.7 percent interest per annum.

Local Loan : 13 year repayment period including 3 year grace period with 11 percent interest per annum and in amortization period, PWA pays only interest part and principal repayments are depended on national government contribution.

Table 13-1-3 to 13-1-5 show the detail debt service for recommended financing plan and Table 13-1-6 shows summarized project cost and funding allocation of financing plan.

Table 13-1-3 Debt Services
for Foreign Portion

(Unit : Baht x 1000)

Year	Capital	Interest	Total Annual Repayment	Balance of Capital
1990	0	0	0	0
1991	0	0	0	0
1992	0	13	13	493
1993	0	134	134	4,959
1994	0	855	855	31,670
1995	0	855	855	31,670
1996	0	855	855	31,670
1997	0	855	855	31,670
1998	0	855	855	31,670
1999	0	855	855	31,670
2000	0	855	855	31,670
2001	0	855	855	31,670
2002	1,215	855	2,070	31,670
2003	1,248	822	2,070	30,455
2004	1,282	789	2,070	29,207
2005	1,316	754	2,070	27,926
2006	1,352	718	2,070	26,609
2007	1,388	682	2,070	25,258
2008	1,426	644	2,070	23,870
2009	1,464	606	2,070	22,444
2010	1,504	566	2,070	20,980
2011	1,544	526	2,070	19,476
2012	1,586	484	2,070	17,932
2013	1,629	441	2,070	16,346
2014	1,673	397	2,070	14,717
2015	1,718	352	2,070	13,045
2016	1,764	306	2,070	11,327
2017	1,812	258	2,070	9,562
2018	1,861	209	2,070	7,750
2019	1,911	159	2,070	5,889
2020	1,963	107	2,070	3,978
2021	2,016	54	2,070	2,016
Total	31,670	16,720	48,390	

Table 13-1-4 Debt Services
for Local Portion

(Unit : Baht x 1000)

Year	Capital	Interest	Total Annual Repayment	Balance of Capital
1990	0	0	0	0
1991	0	0	0	0
1992	0	28	28	259
1993	0	325	325	2,956
1994	0	1,830	1,830	16,640
1995	995	1,830	2,825	16,640
1996	1,105	1,721	2,825	15,644
1997	1,226	1,599	2,825	14,540
1998	1,361	1,465	2,825	13,314
1999	1,511	1,315	2,825	11,953
2000	1,677	1,149	2,825	10,442
2001	1,861	964	2,825	8,766
2002	2,066	759	2,825	6,904
2003	2,293	532	2,825	4,839
2004	2,545	280	2,825	2,545
Total	16,640	13,798	30,438	

Table 13-1-5 Debt Services

(Unit : Baht x 1000)

Year	Capital	Interest	Total Annual Repayment	Balance of Capital
1990	0	0	0	0
1991	0	0	0	0
1992	0	42	42	752
1993	0	459	459	7,915
1994	0	2,685	2,685	48,310
1995	995	2,685	3,681	48,310
1996	1,105	2,576	3,681	47,314
1997	1,226	2,454	3,681	46,210
1998	1,361	2,320	3,681	44,984
1999	1,511	2,170	3,681	43,623
2000	1,677	2,004	3,681	42,112
2001	1,861	1,819	3,681	40,436
2002	3,281	1,615	4,896	38,574
2003	3,541	1,355	4,896	35,294
2004	3,827	1,069	4,896	31,753
2005	1,316	754	2,070	27,926
2006	1,352	718	2,070	26,609
2007	1,388	682	2,070	25,258
2008	1,426	644	2,070	23,870
2009	1,464	606	2,070	22,444
2010	1,504	566	2,070	20,980
2011	1,544	526	2,070	19,476
2012	1,586	484	2,070	17,932
2013	1,629	441	2,070	16,346
2014	1,673	397	2,070	14,717
2015	1,718	352	2,070	13,045
2016	1,764	306	2,070	11,327
2017	1,812	258	2,070	9,562
2018	1,861	209	2,070	7,750
2019	1,911	159	2,070	5,889
2020	1,963	107	2,070	3,978
2021	2,016	54	2,070	2,016
Total	48,310	30,519	78,828	

Table 13-1-6 Project Cost, Disbursement Schedule and Funding Allocation

a. Project Cost and Disbursement Schedule

(Unit : Baht x 1,000)

Year	Foreign Portion	Local Portion	Total
1990	0	0	0
1991	0	0	0
1992	345	665	1,010
1993	3,126	6,734	9,860
1994	18,698	35,381	54,079
1995	0	0	0
1996	0	0	0
1997	0	0	0
1998	0	0	0
1999	0	0	0
2000	0	0	0
Total	22,169	42,780	64,949

b. Funding allocation

(Unit : Baht x 1,000)

Year	Bilateral Loan	Local Loan	PWA's Equity	Total
1990	0	0	0	0
1991	0	0	0	0
1992	493	285.5	285.5	1,010
1993	4,466	2,697.0	2,697.0	9,860
1994	26,711	13,684.0	13,684.0	54,079
1995	0	0	0	0
1996	0	0	0	0
1997	0	0	0	0
1998	0	0	0	0
1999	0	0	0	0
2000	0	0	0	0
Total	31,670	16,639.5	16,639.5	64,949

13.3 Revenue Plan

1) Water Sales

The revenue is required to be raised by waterworks to meet the annual cash requirement after the construction of the systems. Such annual cash requirements normally include the operation and maintenance costs as well as debt service if a certain loan is made to finance the capital costs.

a. PWA Water Tariff Schedule

Water tariffs are collected by reading water meters with the exception of negligible direct sale fees. PWA has three major sources of tariff revenue: namely, water sales, service charges and connection fees. Revenue from these tariffs contribute 95 percent to the total revenue of PWA. All the waterworks have the same income structure as this. PWA also applies the same water tariff structure to all waterworks. Table 13-1-7 shows the current levels of water tariff structure.

Table 13-1-7 Present Water Tariff Structure

Consumption (cu m / mo)	Tariff (Baht / cu m)
0 - 10	3.75
11 - 20	4.50
21 - 30	6.50
31 - 50	7.50
51 - 80	8.00
81 - 100	8.50
101 - 300	9.00
300 - 1,000	9.25
1,100 - 2,000	9.50
2,001 - 3,000	9.75
3,001 and above	10.00

Connection Fees and Service Charges:

These fees and charges are of the nature which cover actual expenses to be borne by the consumers for connection work. PWA accounts these fees and charges as revenue sources as they actually form a significant part of its revenue.

Present Connection Fees:

The minimum connection fee is set at 2,050 Baht for 1/2" diameter pipe with a length of 10 meters. The additional fee can be added substantially to the total cost of a connection - for example a new 1/2" connection with a length of 30 meters from the main pipe which could cost over double that for an equivalent connection 10 meters from the main. The additional fees are not charged according to a fixed scale, but instead are levied by PWA on an ad hoc basis charges for the labor and material costs.

Present connection charge and estimated connection fees are shown in Tables 13-1-8 and 13-1-9, respectively.

Table 13-1-8 Present Connection Charge

Size of Connection	Basis Connection Fee (for connection less than 10 meters from main pipe) (Baht / conn.)
1/2"	2,050
3/4"	2,750
1"	3,750
1-1/2"	6,690
2"	9,575
2-1/2"	13,075
3"	15,495
4"	21,455
6"	30,025

Note: Basic connection fee is applied to the connection less than 10 m from the main pipe

Table 13-1-9 Connection Fee

Size of Conn. (inch)	0.5	0.75	1	1.5	2	2.5	3	4	6	
Conn. charge (Bath/conn.)	2,050	2,750	3,750	6,690	9,575	13,075	15,495	21,455	30,025	Conn. Charge
Year	No. of Conn.									(Bath x 1000)
1990	0	0	0	0	0	0	0	0	0	0
1991	205	14	2	3	0	0	0	0	0	486
1992	176	1	0	0	0	0	0	0	0	364
1993	176	1	0	0	0	0	0	0	0	364
1994	176	1	0	0	0	0	0	0	0	364
1995	176	1	0	0	0	0	0	0	0	364
1996	176	4	0	1	0	1	0	0	0	392
1997	205	0	0	0	0	0	0	0	0	420
1998	205	1	0	0	0	0	0	0	0	423
1999	205	1	0	0	0	0	0	0	0	423
2000	205	1	0	0	0	0	0	0	0	423
2001	204	5	1	2	0	0	0	0	0	449
2002	274	1	0	1	0	0	0	0	0	571
2003	274	1	0	1	0	0	0	0	0	571
2004	274	2	0	1	0	0	0	0	0	574
2005	274	1	0	1	0	0	0	0	0	571
2006	275	6	2	0	0	0	0	0	0	588
2007	305	4	0	0	0	0	0	0	0	636
2008	305	3	0	1	0	0	0	0	0	640
2009	305	4	0	1	0	0	0	0	0	643
2010	305	4	0	1	0	0	0	0	0	643
2011	303	2	1	0	0	0	0	0	0	630

Note : 0.5 inch ; Domestic
0.75 inch ; Commercial, Industrial & Others
1 inch ; School
1.5 inch ; Government
2.5 inch ; Hospital

Service charges are levied on consumers according to the size of their connection,and increase rapidly for larger connections. The service charge is levied monthly and is fixed, regardless of the level of water consumption during a given month. Present service charges are shown in Table 13-1-10 below.

Table 13-1-10 Present Service Charge

Size of connection	Monthly Service Charge (Baht)
1/2"	10
3/4"	15
1"	30
1-1/2"	60
2"	100
2-1/2"	120
3"	160
4" and above	200

Service charges are estimated by multiplying the number of connections by the service charge per connection as shown in Table 13-1-11.

Table 13-1-11 Service Charge

Size of Conn. (inch)	0.5	0.75	1	1.5	2	2.5	3	4 & above	
Conn. charge (Bath/month.)	10	15	30	60	100	120	160	200	Total Service Charge
Year	No. of Conn.								(Bath x 1000)
1990	4,123	118	18	40	0	1	0	0	553
1991	4,328	132	20	43	0	1	0	0	583
1992	4,504	133	20	43	0	1	0	0	604
1993	4,680	134	20	43	0	1	0	0	625
1994	4,856	135	20	43	0	1	0	0	647
1995	5,032	136	20	43	0	1	0	0	668
1996	5,208	140	20	44	0	2	0	0	692
1997	5,413	140	20	44	0	2	0	0	717
1998	5,618	141	20	44	0	2	0	0	741
1999	5,823	142	20	44	0	2	0	0	766
2000	6,028	143	20	44	0	2	0	0	791
2001	6,232	148	21	46	0	2	0	0	818
2002	6,506	149	21	47	0	2	0	0	852
2003	6,780	150	21	48	0	2	0	0	886
2004	7,054	152	21	49	0	2	0	0	920
2005	7,328	153	21	50	0	2	0	0	953
2006	7,603	159	23	50	0	2	0	0	988
2007	7,908	163	23	50	0	2	0	0	1,025
2008	8,213	166	23	51	0	2	0	0	1,063
2009	8,518	170	23	52	0	2	0	0	1,101
2010	8,823	174	23	53	0	2	0	0	1,139
2011	9,126	176	24	53	0	2	0	0	1,176

Note : 0.5 inch ; Domestic
0.75 inch ; Commercial, Industrial & Others
1 inch ; School
1.5 inch ; Government
2.5 inch ; Hospital

b. Project Water Sales Revenue

Water Sales of the waterworks are estimated as tabulated in Table 13-1-12 with the following conditions adopted in the forecasting.

i) Water tariffs will remain unchanged until 2020.

ii) Water sales are estimated by use for domestic, commercial, institutional, industrial and other use as predicted in each year.

iii) Water sales are calculated from the monthly average water consumption multiplied by water tariff.

In the PWA's water tariff system, water charge is levied on consumers according to metered water consumption after every month. Charging method is to levy a progressive method for the amount metered. Prior to the increases, charges were levied on a sliding scale. Thus, for example, a consumer using 25 cu m of water in a month would pay 3.75 Baht per cu m for the first 10 cu m, 4.50 Baht per cu m for the next 10 cu m and 6.50 Baht per

Table 13-1-12 Water Sales

(1)Domestic

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water Sales (cu.m/d)	2,826	2,948	3,035	3,124	3,215	3,308	3,402	3,499	3,597	3,697	3,800	3,905
(cu.m/month)	84,780	88,440	91,050	93,720	96,450	99,240	102,060	104,970	107,910	110,910	114,000	117,150
No.of Connections	4,123	4,328	4,504	4,680	4,856	5,032	5,208	5,413	5,618	5,823	6,028	6,232
Water Cons./Conn.	20.56	20.43	20.22	20.03	19.86	19.72	19.60	19.39	19.21	19.05	18.91	18.80
Water Sales(*1,000Baht)	355	369	378	387	398	409	420	432	435	456	468	480

(2)Governmental/Institutional

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water Sales (cu.m/d)	1,708	1,717	1,727	1,738	1,747	1,757	1,769	1,784	1,799	1,815	1,831	1,846
(cu.m/month)	51,240	51,510	51,810	52,140	52,410	52,710	53,070	53,520	53,970	54,450	54,930	55,380
No.of Connections	59	64	64	64	64	64	66	66	66	66	66	69
Water Cons./Conn.												
Water Sales(*1,000Baht)	461	462	465	467	470	474	475	479	483	488	492	495

(3)Commercial

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water Sales (cu.m/d)	305	307	309	310	312	314	316	319	322	325	328	331
(cu.m/month)	9,150	9,210	9,270	9,300	9,360	9,420	9,480	9,570	9,660	9,750	9,840	9,930
No.of Connections	90	102	103	104	105	106	105	106	107	108	109	110
Water Cons./Conn.	101.67	90.29	90.00	89.42	89.14	88.87	90.29	90.28	90.28	90.28	90.28	90.27
Water Sales(*1,000Baht)	65	64	64	64	65	65	66	66	67	67	68	69

(4)Industrial

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water Sales (cu.m/d)	68	70	72	73	75	76	78	80	81	83	84	86
(cu.m/month)	2,040	2,100	2,160	2,190	2,250	2,280	2,340	2,400	2,430	2,490	2,520	2,580
No.of Connections	15	16	16	16	16	16	18	18	18	18	18	20
Water Cons./Conn.	136.00	131.25	135.00	136.88	140.63	142.50	130.00	133.33	135.00	138.33	140.00	129.00
Water Sales(*1,000Baht)	15	16	16	17	17	17	18	18	18	19	19	19

(5)Others

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water Sales (cu.m/d)	45	47	48	49	50	51	52	53	54	55	56	58
(cu.m/month)	1,350	1,410	1,440	1,470	1,500	1,530	1,560	1,590	1,620	1,650	1,680	1,740
No.of Connections	13	14	14	14	14	14	16	16	16	16	16	18
Water Cons./Conn.	103.85	100.71	102.86	105.00	107.14	109.29	97.50	99.38	101.25	103.13	105.00	96.67
Water Sales(*1,000Baht)	10	10	10	11	11	11	11	11	12	12	12	12

Total	906	921	933	946	961	976	990	1,006	1,015	1,042	1,059	1,075

Table 13-1-12 Water Sales (Cont'd)

(1)Domestic

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water Sales (cu.m/d)	4,040	4,178	4,320	4,465	4,614	4,766	4,921	5,080	5,243	5,408
(cu.m/month)	121,200	125,340	129,600	133,950	138,420	142,980	147,630	152,400	157,290	162,240
No.of Connections	6,506	6,780	7,054	7,328	7,603	7,908	8,213	8,518	8,823	9,126
Water Cons./Conn.	18.63	18.49	18.37	18.28	18.21	18.08	17.98	17.89	17.83	17.78
Water Sales(*1,000Baht)	497	513	530	548	566	584	603	622	642	662

(2)Governmental/Institu

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water Sales (cu.m/d)	1,869	1,890	1,912	1,933	1,956	1,984	2,010	2,038	2,066	2,093
(cu.m/month)	56,070	56,700	57,360	57,990	58,680	59,520	60,300	61,140	61,980	62,790
No.of Connections	70	71	72	73	74	75	76	77	78	79
Water Cons./Conn.										
Water Sales(*1,000Baht)	502	507	513	519	525	532	540	546	554	561

(3)Commercial

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water Sales (cu.m/d)	335	339	344	348	352	357	363	368	373	378
(cu.m/month)	10,050	10,170	10,320	10,440	10,560	10,710	10,890	11,040	11,190	11,340
No.of Connections	111	112	113	114	117	119	121	123	125	126
Water Cons./Conn.	90.54	90.80	91.33	91.58	90.26	90.00	90.00	89.76	89.52	90.00
Water Sales(*1,000Baht)	70	70	72	72	73	74	75	76	77	78

(4)Industrial

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water Sales (cu.m/d)	89	91	93	96	99	101	104	107	110	113
(cu.m/month)	2,670	2,730	2,790	2,880	2,970	3,030	3,120	3,210	3,300	3,390
No.of Connections	21	22	23	24	23	24	25	26	27	26
Water Cons./Conn.	127.14	124.09	121.30	120.00	129.13	126.25	124.80	123.46	122.22	130.38
Water Sales(*1,000Baht)	20	20	21	21	22	23	23	24	25	26

(5)Others

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water Sales (cu.m/d)	59	61	62	64	66	67	69	71	73	75
(cu.m/month)	1,770	1,830	1,860	1,920	1,980	2,010	2,070	2,130	2,190	2,250
No.of Connections	18	18	18	18	20	21	22	23	24	23
Water Cons./Conn.	98.33	101.67	103.33	106.67	99.00	95.71	94.09	92.61	91.25	97.83
Water Sales(*1,000Baht)	12	13	13	14	14	14	14	15	15	16

Total	1,101	1,123	1,149	1,174	1,200	1,227	1,255	1,283	1,313	1,343

cu m only for the last 5 cu m above 20 cu m, so that a total payment will be 115 Baht.

13.4 Cash Flow Statement

1) Cash Flow

Table 13-1-13 shows the projected cash flow from 1990 to 2020. Estimate condition of each items to be counted in cash flow are as follows.

a. Cash Inflow

- Government contribution

  capital contribution for interest payment of domestic loan.

- Loan

  Local and foreign loan disbursement is estimated based on the recommended financing plan.

- Water sales, connection charge and service charge.

  Detailed estimation is shown in Table 13-1-9, 13-1-11 and 13-1-12.

- Other income

  This income is including sales of materials, fine penalties and other, and estimated 2 percent of total water sales of each year.

b. Cash Outflow

- Project expenditure

  It is according to capital disbursement schedule for Implementation plan.

- Amortization

  Recommended financing plan is adopted in the debt service calculation.

- Operation & maintenance

  Details are shown in chapter 11.

- Connection expenses

  50 percent of Connection Fee.

- Share of Head Office

Table 13-1-13 Projected Cash Flow at 1989 Price

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Cash Inflow																
Government contribution																
Capital contribution	0	0	0	0	0	995	1,105	1,226	1,361	1,511	1,677	1,861	2,066	2,293	2,545	
Laon	0	0	752	7,163	40,395											
Local loan	0	0	259	2,697	13,684											
Foreign loan	0	0	493	4,466	26,711											
Operating Revenue	11,642	12,342	12,388	12,568	12,774	12,978	13,202	13,450	13,588	13,943	14,176	14,425	14,899	15,203	15,558	15,894
Water Sales	10,872	11,052	11,196	11,352	11,532	11,712	11,880	12,072	12,180	12,504	12,708	12,900	13,212	13,476	13,788	14,088
Connection Fee	0	486	364	364	364	364	392	420	423	423	423	449	571	571	574	571
Service Charge	553	583	604	625	647	668	692	717	741	766	791	818	852	886	920	953
Ohter Income	217	221	224	227	231	234	238	241	244	250	254	258	264	270	276	282
Total Inflow	11,642	12,342	13,139	19,731	53,169	13,973	14,307	14,676	14,949	15,454	15,853	16,286	16,965	17,496	18,103	15,894
Cash Outflow																
Project expenditures																
Local portion	0	0	665	6,734	35,381											
Foreign portion	0	0	345	3,126	18,698											
Amortization																
Principal	0	0	0	0	0	995	1,105	1,226	1,361	1,511	1,677	1,861	3,281	3,541	3,827	1,316
Interest	0	0	42	459	2,685	2,685	2,576	2,454	2,320	2,170	2,004	1,819	1,615	1,355	1,069	754
Operating Expenses	6,745	7,161	7,268	7,445	7,635	7,827	8,213	8,600	9,130	9,510	9,850	10,158	10,556	11,089	11,463	12,059
O & M Cost	3,552	3,685	3,821	3,964	4,114	4,266	4,601	4,932	5,436	5,745	6,040	6,292	6,561	7,035	7,340	7,871
Connection Expenses	0	243	182	182	182	182	196	210	212	212	212	225	286	286	287	286
Share of Head office	3,193	3,233	3,265	3,299	3,339	3,379	3,416	3,458	3,482	3,553	3,598	3,641	3,709	3,768	3,836	3,902
Total Outflow	6,745	7,161	8,320	17,764	64,399	11,507	11,894	12,280	12,811	13,191	13,531	13,838	15,452	15,985	16,359	14,129
Net Cash flow	4,897	5,181	4,819	1,967	-11,230	2,466	2,413	2,396	2,138	2,264	2,323	2,449	1,514	1,511	1,744	1,765
Accumulated	4,897	10,078	14,898	16,865	5,635	8,101	10,513	12,910	15,048	17,312	19,634	22,083	23,596	25,107	26,851	28,616

Table 13-1-13 Projected Cash Flow at 1989 Price (Cont'd)

(Unit: Baht x 1000)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Cash Inflow															
Government contribution															
Capital contribution															
Laon															
Local loan															
Foreign loan															
Operating Revenue	16,264	16,679	17,064	17,448	17,853	18,244	18,244	18,244	18,244	18,244	18,244	18,244	18,244	18,244	18,244
Water Sales	14,400	14,724	15,060	15,396	15,756	16,116	16,116	16,116	16,116	16,116	16,116	16,116	16,116	16,116	16,116
Connection Fee	588	636	640	643	643	630	630	630	630	630	630	630	630	630	630
Service Charge	988	1,025	1,063	1,101	1,139	1,176	1,176	1,176	1,176	1,176	1,176	1,176	1,176	1,176	1,176
Ohter Income	288	294	301	308	315	322	322	322	322	322	322	322	322	322	322
Total Inflow	16,264	16,679	17,064	17,448	17,853	18,244	18,244	18,244	18,244	18,244	18,244	18,244	18,244	18,244	18,244
Cash Outflow															
Project expenditures															
Local portion															
Foreign portion															
Amortization															
Principal	1,352	1,388	1,426	1,464	1,504	1,544	1,586	1,629	1,673	1,718	1,764	1,812	1,861	1,911	1,963
Interest	718	682	644	606	566	526	484	441	397	352	306	258	209	159	107
Operating Expenses	11,480	13,406	14,131	14,641	15,252	16,087	16,087	16,087	16,087	16,087	16,087	16,087	16,087	16,087	16,087
O & M Cost	8,215	9,045	9,694	10,128	10,660	11,422	11,422	11,422	11,422	11,422	11,422	11,422	11,422	11,422	11,422
Connection Expenses	294	318	320	322	322	315	315	315	315	315	315	315	315	315	315
Share of Head office	2,971	4,043	4,117	4,191	4,270	4,350	4,350	4,350	4,350	4,350	4,350	4,350	4,350	4,350	4,350
Total Outflow	13,550	15,476	16,201	16,711	17,322	18,157	18,157	18,157	18,157	18,157	18,157	18,157	18,157	18,157	18,157
Net Cash flow	2,714	1,203	863	737	532	87	87	87	87	87	87	87	87	87	87
Accumulated	31,330	32,534	33,397	34,135	34,666	34,754	34,841	34,928	35,015	35,103	35,190	35,277	35,365	35,452	35,539

As clearly shown in this table, in 1994 the net cash flow ended in a defect.

After 1994, net annual revenue surpluses are forecasted large enough cover throughout construction period and operation and expenditures in the maintenance period, amortization cost and operating expenses.

The result of this cash flow statement reveals that the annual net cash flow will continuously raise profit surpluses throughout after 1994, with cumulative surplus increasing to 34,754 tousand Baht in 2011 and 35,539 thousand Baht in 2020. This accumulated surplus is almost two times as large as the gross operating revenue of the year 2011.

This result may demonstrate the simple financial feasibility of this project.

2) Share of Head and Regional Office Overhead Expenses

PWA is administratively, technically, economically and financially independent from the central government. Therfore, in order that total financial independence can be achieved by PWA in the future, administrative expenses and consignment fee shall be charged to the revenue of each waterworks.

In view of above, it is recommended that share allocation of administrative expenses shall be calculated based on number of waterworks and gross revenue of each waterworks.

3) Unit Cost of Water

As shown in Table 13-1-14, the unit cost of water before depreciation will register 5.46 Baht per cu m in 2011 or equal to 94 percent of the average unit water cost from year 1990 to 2011 and almost second level of present water tariff structure of PWA. And average unit water cost from 1990 to 2020 is projected to stand at 5.69 Baht or third level of present water tariff.

4) Average Water Rate

In view of revenue aspects, average water tariff is calculated basedon water sales and it is shown in Table 13-1-15.

Table 13-1-14 Unit Cost of Water

(Unit :Baht x 1000)

year	Water Consum. (cu.m/day)	Capital Investement	Operating Expenses	Total Expenses	Unit Water Cost (Baht/cu.m)
1990	4,952	0	6,745	6,745	3.73
1991	5,089	0	7,161	7,161	3.86
1992	5,190	1,010	7,268	8,278	4.37
1993	5,294	9,860	7,445	17,305	8.96
1994	5,399	54,079	7,635	61,714	31.32
1995	5,506	0	7,827	7,827	3.89
1996	5,616	0	8,213	8,213	4.01
1997	5,733	0	8,600	8,600	4.11
1998	5,853	0	9,130	9,130	4.27
1999	5,975	0	9,510	9,510	4.36
2000	6,099	0	9,850	9,850	4.42
2001	6,226	0	10,158	10,158	4.47
2002	6,391	0	10,556	10,556	4.53
2003	6,560	0	11,089	11,089	4.63
2004	6,732	0	11,463	11,463	4.67
2005	6,907	0	12,059	12,059	4.78
2006	7,086	0	11,480	11,480	4.44
2007	7,275	0	13,406	13,406	5.05
2008	7,468	0	14,131	14,131	5.18
2009	7,664	0	14,641	14,641	5.23
2010	7,864	0	15,252	15,252	5.31
2011	8,068	0	16,087	16,087	5.46
2012	8,068	0	16,087	16,087	5.46
2013	8,068	0	16,087	16,087	5.46
2014	8,068	0	16,087	16,087	5.46
2015	8,068	0	16,087	16,087	5.46
2016	8,068	0	16,087	16,087	5.46
2017	8,068	0	16,087	16,087	5.46
2018	8,068	0	16,087	16,087	5.46
2019	8,068	0	16,087	16,087	5.46
2020	8,068	0	16,087	16,087	5.46
Average Unit Water Cost (1990-2020) :					5.69

Table 13-1-15 Average Water Tariff

Year	Water Consumption (cu.m/d)	Water Sales (1000 Baht /year)	Average Water Tariff (Baht/cu.m)
1990	4,952	10,872	6.02
1991	5,089	11,052	5.95
1992	5,190	11,196	5.91
1993	5,294	11,352	5.87
1994	5,399	11,532	5.85
1995	5,506	11,712	5.83
1996	5,616	11,880	5.80
1997	5,733	12,072	5.77
1998	5,853	12,180	5.70
1999	5,975	12,504	5.73
2000	6,099	12,708	5.71
2001	6,226	12,900	5.68
2002	6,391	13,212	5.66
2003	6,560	13,476	5.63
2004	6,732	13,788	5.61
2005	6,907	14,088	5.59
2006	7,086	14,400	5.57
2007	7,275	14,724	5.54
2008	7,468	15,060	5.52
2009	7,664	15,396	5.50
2010	7,864	15,756	5.49
2011	8,068	16,116	5.47
2012	8,068	16,116	5.47
2013	8,068	16,116	5.47
2014	8,068	16,116	5.47
2015	8,068	16,116	5.47
2016	8,068	16,116	5.47
2017	8,068	16,116	5.47
2018	8,068	16,116	5.47
2019	8,068	16,116	5.47
2020	8,068	16,116	5.47

APPENDICES

APPENDIX A-1-1

Meteorological Data

Meteorological Data

Table A1-1-1 : Monthly Rainfall at Thung Song

Code; RH
Station; Amphur Thung Song, Nakorn Sri Thammarat

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1953	119.0	78.0	33.0	5.0	434.0	238.0	162.0	87.0	274.0	502.0	413.0	26.0	2371.0
1954	49.0	0.0	30.0	39.0	99.0	135.0	371.0	97.0	108.0	68.0	68.0	44.0	1108.0
1955	21.0	28.0	31.0	52.0	83.0	183.0	111.0	176.0	243.0	337.0	346.0	82.0	1693.0
1956	31.0	18.0	18.0	163.0	219.0	156.0	113.0	170.0	280.0	429.0	145.0	168.0	1910.0
1957	29.0	47.0	82.0	88.0	168.0	64.0	274.0	114.0	211.0	285.0	127.0	190.0	1679.0
1958	17.0	5.0	19.0	16.0	238.0	130.0	78.0	315.0	218.0	490.0	627.0	8.0	2161.0
1959	28.0	0.0	79.0	134.0	171.0	99.0	176.0	158.0	142.0	257.0	286.0	291.0	1821.0
1960	28.0	24.0	79.0	159.0	104.0	93.0	229.0	123.0	149.0	247.0	207.0	97.0	1539.0
1961	21.0	73.0	52.0	110.0	196.0	207.0	208.0	120.0	143.0	315.0	382.0	241.0	2068.0
1962	101.0	19.0	37.0	57.0	94.0	138.0	240.0	303.0	156.0	433.0	218.0	106.0	1902.0
1963	56.0	0.0	0.0	0.0	45.0	180.0	130.0	212.0	272.0	436.0	314.0	98.0	1743.0
1964	153.0	55.0	49.0	22.0	368.0	96.0	266.0	210.0	259.0	226.0	201.0	416.0	2321.0
1965	10.0	55.0	68.0	157.0	226.0	173.0	246.0	272.0	363.0	221.0	413.0	304.0	2508.0
1966	81.0	70.0	236.0	48.0	153.0	248.0	166.0	244.0	165.0	276.0	550.0	408.0	2645.0
1967	185.0	10.0	1.0	58.0	90.0	151.0	341.0	192.0	149.0	287.0	264.0	54.0	1782.0
1968	11.0	6.0	118.0	53.0	301.0	229.0	215.0	300.0	146.0	344.0	53.0	11.0	1787.0
1969	57.0	5.0	36.0	27.0	215.0	230.0	164.0	226.0	340.0	281.0	403.0	117.0	2101.0
1970	188.0	14.0	4.0	0.0	150.0	125.0	197.0	294.0	199.0	294.0	465.0	217.0	2147.0
1971	0.0	47.0	147.0	10.0	205.0	145.0	80.0	233.0	269.0	547.0	219.0	284.0	2186.0
1972	14.0	27.0	7.0	45.0	235.0	289.0	124.0	104.0	402.0	288.0	317.0	95.0	1947.0
1973	11.0	0.0	19.0	45.0	271.0	139.0	353.0	118.0	211.0	321.0	401.0	207.0	2096.0
1974	0.0	46.0	14.0	134.0	505.0	162.0	114.0	172.0	197.0	281.0	364.0	417.0	2406.0
1975	412.0	89.0	0.0	67.0	356.0	285.0	154.0	102.0	155.0	223.0	240.0	123.0	2206.0
1976	1.0	0.0	32.0	193.0	237.0	101.0	151.0	276.0	206.0	287.0	456.0	72.0	2012.0
1977	40.0	3.0	3.0	8.0	98.0	75.0	173.0	231.0	280.0	210.0	387.0	57.0	1565.0
1978	21.0	0.0	13.0	80.0	170.0	238.0	272.0	135.0	287.0	309.0	71.0	117.0	1713.0
1979	31.0	3.0	0.0	89.0	170.0	150.0	422.0	201.0	320.0	81.0	306.0	28.0	1801.0
1980	12.0	0.0	143.0	231.0	190.0	225.0	204.0	321.0	101.0	243.0	471.0	60.0	2201.0
1981	9.0	18.0	0.0	201.0	402.0	92.0	138.0	87.0	176.0	130.0	329.0	213.0	1795.0
1982	0.0	0.0	44.0	458.0	243.0	69.0	322.0	149.0	205.0	197.0	178.0	75.0	1940.0
1983	30.0	0.0	30.0	0.0	176.0	211.0	127.0	228.0	235.0	211.0	147.0	97.0	1492.0
1984	158.0	64.0	99.0	159.0	226.0	210.0	254.0	116.0	131.0	105.0	236.0	308.0	2066.0
1985	0.0	27.0	38.0	207.0	243.0	222.0	191.0	139.0	217.0	272.0	259.0	127.0	1942.0
1986	9.0	0.0	109.0	62.0	406.0	134.0	145.0	188.0	639.0	297.0	235.0	100.0	2324.0
1987	19.2	0.0	0.0	78.2	207.0	118.4	112.0	316.8	208.2	214.3	146.8	448.6	1869.5

Source : Meteorological Department

Table A1-1-2 : Monthly Rainfall at Ron Piboon

Code; RM 3003
Station; Amphur Ron Piboon, Nakhon Sri Thammarat

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1956	102.8	58.2	27.5	205.2	93.5	153.1	87.5	109.8	164.4	428.9	220.7	391.5	2043.1
1957	74.7	75.6	109.3	45.5	320.0	8.7	56.2	66.7	61.4	357.7	359.4	356.9	1892.1
1958	28.5	19.0	7.5	49.1	216.9	40.2	58.0	186.0	61.6	274.4	914.9	100.4	1956.5
1959	105.1	0.0	178.4	137.9	108.3	0.0	0.0	208.5	61.1	396.2	556.9	32.2	1784.6
1960	186.8	69.9	60.4	0.0	77.0	81.1	138.3	0.0	80.4	-	-	-	-
1961	105.7	0.0	7.3	0.0	84.0	0.0	0.0	33.5	93.2	133.1	411.0	-	-
1962	137.9	0.0	-	-	-	-	-	-	-	-	-	-	-
1963	-	-	-	-	-	-	-	-	-	-	-	-	-
1964	-	9.0	3.5	0.0	190.7	32.3	10.5	63.5	0.0	68.6	93.6	-	-
1965	-	-	-	-	-	-	-	-	-	-	-	-	-
1966	63.4	0.0	12.4	79.6	0.0	0.0	0.0	24.0	126.9	342.0	475.8	179.6	1303.7
1967	-	-	-	-	-	-	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	-	-	-	-	-	-	-
1969	194.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	210.0	411.4	0.0	816.0
1970	0.0	0.0	12.2	117.1	199.9	54.4	91.7	106.2	183.2	176.9	664.7	233.5	1839.8
1971	5.2	0.0	0.0	0.0	0.0	8.0	44.0	40.1	44.4	528.1	130.4	1072.4	1872.6
1972	51.7	0.0	0.0	19.8	54.0	160.7	56.2	0.0	154.5	82.8	351.4	255.3	1186.4
1973	24.2	0.0	114.4	18.7	156.0	29.7	13.2	9.9	70.6	348.7	681.1	520.2	1986.7
1974	7.7	9.0	18.4	73.4	292.1	44.0	4.9	68.9	63.7	183.9	532.2	729.0	2027.2
1975	1362.9	49.5	0.0	9.4	62.8	103.8	103.0	33.5	71.5	263.0	491.0	272.0	2822.4
1976	0.0	0.0	0.0	130.9	90.0	52.0	180.5	138.0	102.1	273.0	585.0	144.0	1695.5
1977	78.0	0.0	0.0	0.0	47.5	114.0	9.0	108.5	155.5	392.5	552.5	222.0	1679.5
1978	104.0	0.0	0.0	105.5	164.0	18.0	28.0	95.0	81.0	250.3	230.0	105.0	1180.8
1979	80.0	8.0	0.0	207.2	55.5	190.0	58.0	233.0	178.4	266.1	580.1	284.6	2140.9
1980	25.0	0.0	82.2	115.5	125.8	49.5	51.0	120.5	326.0	124.5	530.5	256.7	1807.2
1981	0.0	0.0	31.0	100.0	230.5	34.5	-	-	-	-	-	-	-
1982	45.0	0.0	8.2	0.0	185.0	8.6	77.6	34.8	63.3	180.1	350.7	154.9	1108.2
1983	8.9	0.0	0.0	4.9	106.1	71.8	12.2	31.5	109.3	75.0	346.5	271.2	1037.4
1984	240.1	129.7	110.2	158.6	47.7	93.6	206.0	-	-	-	-	-	-
1985	8.5	51.0	87.7	205.9	105.3	117.4	49.7	24.9	77.5	100.0	406.1	198.3	1432.3
1986	45.7	0.0	0.0	167.4	245.0	0.0	18.1	91.6	259.0	239.6	384.2	220.8	1671.4
1987	65.0	0.0	8.2	22.8	89.8	118.9	13.5	184.7	246.6	231.8	204.7	755.9	1941.9

Source : Meteorological Department

Table A1-1-3 : Monthly Rainfall at Chawang

Code; RH 3007
Station; Amphur Chawang, Nakorn Sri Thammarat

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1956	18.2	5.8	25.7	65.6	358.2	294.2	303.8	171.9	250.0	304.6	169.5	127.2	2094.7
1957	32.0	21.1	38.2	154.7	204.8	190.7	214.5	192.5	334.4	223.2	127.5	104.8	1838.4
1958	0.0	0.0	0.0	66.3	273.1	340.1	132.6	282.9	364.2	434.8	542.0	0.0	2436.0
1959	10.3	10.5	56.3	72.1	86.0	168.8	280.8	208.3	201.1	223.7	176.5	142.3	1636.7
1960	0.0	10.5	0.0	67.0	127.6	242.0	361.5	282.4	261.7	314.0	174.2	0.0	1840.9
1961	15.3	0.0	32.5	83.1	223.7	140.5	222.5	200.9	259.9	448.5	321.8	214.7	2163.4
1962	0.0	0.0	40.0	75.4	183.8	229.8	343.4	249.7	388.4	435.2	77.3	0.0	2023.0
1963	0.0	0.0	0.0	0.0	45.8	200.3	78.0	291.3	325.1	443.4	299.7	149.6	1833.2
1964	0.0	0.0	0.0	0.0	487.8	163.6	312.6	383.2	336.2	406.3	170.6	253.6	2513.9
1965	0.0	48.5	0.0	135.6	574.9	193.8	284.2	224.3	461.1	272.5	447.8	354.5	2997.2
1966	0.0	0.0	169.4	59.0	110.1	193.0	155.6	173.4	155.0	438.1	326.6	271.3	2051.5
1967	154.7	0.0	10.2	26.0	131.1	258.9	188.1	272.2	171.0	209.7	194.7	46.7	1663.3
1968	-	-	-	-	-	-	-	-	71.2	71.2	12.8	15.0	-
1969	61.3	6.4	20.5	45.8	161.1	192.2	233.8	139.0	228.2	76.5	253.8	63.7	1482.3
1970	50.5	35.0	0.0	2.0	122.9	91.4	212.7	388.6	353.8	196.7	198.3	152.2	1804.1
1971	0.0	21.8	84.9	9.3	131.2	208.0	84.2	133.8	110.0	266.0	126.1	83.9	1259.2
1972	0.0	57.0	58.0	65.1	159.4	147.1	116.9	198.2	208.8	181.2	142.1	126.6	1460.4
1973	0.0	12.5	7.7	64.6	180.2	294.4	283.3	194.7	283.0	256.3	-	-	-
1974	-	-	-	-	-	165.5	203.4	200.0	162.6	265.0	234.2	-	-
1975	0.0	0.0	0.0	46.9	265.7	208.8	112.2	130.5	264.4	251.5	225.6	41.7	1547.3
1976	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	44.2	0.0	71.1	54.0	194.3	207.4	210.5	156.4	237.1	244.1	84.9	88.5	1592.5
1979	5.6	4.0	0.0	95.2	216.6	157.4	389.1	176.4	230.8	55.7	241.9	1.9	1574.6
1980	5.9	21.3	62.0	151.4	221.4	202.5	309.6	330.7	356.6	211.9	322.3	54.3	2249.9
1981	0.0	34.8	1.0	123.6	303.9	152.1	148.7	61.0	-	375.5	313.3	91.4	-
1982	0.0	13.3	67.6	100.4	258.7	163.5	297.6	211.1	198.5	233.7	149.4	62.2	1756.0
1983	8.5	0.0	87.9	13.7	218.7	244.1	218.5	194.9	234.9	190.7	148.8	60.2	1620.9
1984	68.2	27.8	92.5	167.8	192.1	189.9	255.4	64.6	166.0	315.3	251.2	248.8	2039.6
1985	0.0	20.8	29.6	131.5	253.7	158.1	56.3	186.8	324.1	283.6	191.5	66.3	1702.3
1986	6.0	14.0	43.5	143.0	229.4	204.3	195.8	270.1	455.5	389.7	261.2	41.0	2253.5
1987	16.4	0.0	2.8	120.9	278.4	162.2	54.6	291.9	261.4	184.0	211.1	239.2	1822.9

Source : Meteorological Department

Table A1-1-4 : Monthly Rainfall at Lan Saka

Code; RM 3008
Station; Amphur Lan Saka, Nakorn Sri Thammarat

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1968	29.4	1.6	-	172.6	130.8	69.6	110.9	8.2	30.1	391.7	243.6	127.4	-
1969	41.2	83.5	155.7	85.2	145.2	148.3	51.4	83.2	186.9	162.0	847.1	245.1	2234.8
1970	77.1	16.2	142.2	72.8	116.7	80.2	201.2	172.4	199.5	119.8	357.2	278.2	1833.5
1971	43.3	11.5	164.2	98.6	152.7	130.1	90.5	62.2	38.8	299.1	135.3	475.5	1701.8
1972	59.3	37.0	20.0	140.2	23.2	40.9	36.0	133.6	15.5	403.5	952.5	314.6	2176.3
1973	190.5	10.5	120.7	71.4	251.2	30.6	3.5	0.0	19.4	227.1	467.4	107.6	1499.9
1974	0.0	10.0	12.5	48.3	200.1	75.1	58.9	68.4	92.6	98.0	371.0	706.2	1741.1
1975	865.6	176.0	26.0	37.0	170.6	59.0	54.0	41.0	92.0	221.0	441.0	292.0	2475.2
1976	0.0	0.0	0.0	64.0	91.5	78.0	77.0	113.0	142.0	320.0	904.0	131.0	1920.5
1977	262.0	42.0	82.0	0.0	89.0	97.0	83.0	32.0	194.0	276.0	709.0	185.0	2051.0
1978	104.0	12.0	22.0	117.0	146.0	0.0	59.0	41.0	63.0	158.0	289.8	476.4	1488.2
1979	183.3	0.0	0.0	108.7	45.7	148.0	192.6	129.4	41.0	58.8	142.4	21.3	1071.2
1980	10.0	0.0	26.0	9.1	98.4	164.2	66.8	10.0	44.1	146.4	568.9	242.1	1386.0
1981	6.7	0.0	0.0	102.8	81.9	9.6	43.6	25.8	187.8	314.1	293.2	508.5	1574.0
1982	0.0	27.0	19.7	181.3	0.0	0.0	14.3	27.1	41.9	228.3	212.7	85.1	837.4
1983	254.6	24.0	106.9	117.0	125.3	158.6	65.4	120.6	120.4	210.1	296.7	521.5	2121.1
1984	251.3	152.6	84.6	92.9	123.6	67.4	122.8	74.9	143.0	145.8	614.0	528.2	2501.1
1985	68.1	98.6	148.1	119.0	153.0	134.6	91.8	57.0	107.8	199.8	473.3	396.8	2047.9
1986	55.0	11.0	12.2	51.4	302.5	57.5	50.7	106.4	542.1	213.3	521.3	328.9	2252.3
1987	152.2	2.0	59.9	80.0	243.1	122.4	13.8	232.5	22.0	233.1	256.1	897.2	2314.3

Source : Meteorological Department

Table A1-1-5 : Monthly Rainfall at Nakorn Si Thammarat

Code; RH 3301
Station; Amphur Muang, Nakorn Si Thammarat

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1951	272.7	11.5	25.6	76.9	0.0	87.5	196.4	124.3	300.5	328.0	416.3	1160.5	3000.2
1952	123.0	0.0	53.4	166.9	142.3	86.5	42.6	199.8	60.6	250.3	552.2	582.6	2260.2
1953	545.4	219.2	21.0	120.3	167.1	55.6	88.4	181.2	168.0	204.4	984.8	481.1	3236.5
1954	132.9	61.9	75.7	58.1	178.9	26.7	196.2	98.6	124.9	165.4	181.0	670.8	1971.1
1955	308.1	36.3	1.2	82.8	131.5	43.9	159.9	168.4	199.8	407.1	476.3	196.9	2212.2
1956	133.2	69.2	41.9	179.5	318.0	160.7	106.7	72.9	140.1	507.2	358.8	713.8	2802.0
1957	91.2	4.0	73.5	144.6	246.8	35.0	104.0	35.9	22.8	300.8	304.6	579.7	1942.9
1958	55.5	12.6	1.6	6.2	108.3	31.9	43.9	210.7	142.2	358.3	1062.7	223.3	2257.2
1959	91.4	0.0	88.9	111.3	112.7	172.9	126.3	149.6	144.6	631.8	463.2	422.1	2514.8
1960	203.5	96.5	8.5	111.1	217.9	46.2	157.1	127.1	127.0	289.7	379.2	395.9	2159.7
1961	125.8	105.3	48.9	228.5	118.8	76.5	57.6	38.4	204.3	208.1	874.5	617.4	2704.1
1962	253.2	66.9	106.2	23.0	206.0	37.5	85.2	130.8	61.2	415.0	580.8	365.8	2331.6
1963	197.6	8.3	0.8	27.5	30.3	134.5	115.3	100.2	254.7	639.5	733.2	338.7	2580.6
1964	245.6	129.8	36.2	30.9	267.7	103.4	176.7	106.3	80.6	99.5	331.8	486.0	2094.5
1965	44.2	31.8	92.0	151.4	271.4	56.1	100.5	169.7	75.9	397.0	613.4	652.5	2655.9
1966	170.8	54.1	74.6	16.5	52.1	107.0	137.2	113.7	330.4	346.5	846.9	870.7	3120.5
1967	522.7	179.0	74.2	119.4	234.7	61.5	142.6	76.8	98.6	387.1	648.1	233.3	2778.0
1968	13.7	2.3	3.1	54.8	126.0	198.0	170.3	44.8	142.7	342.5	360.0	217.2	1675.4
1969	163.9	22.1	14.6	50.6	139.1	39.9	38.4	53.2	147.1	407.4	848.6	417.3	2342.2
1970	387.7	15.3	57.9	125.3	221.8	135.6	129.8	159.7	195.4	313.6	621.3	581.4	2944.8
1971	21.4	73.7	118.2	23.9	120.5	42.1	23.2	78.2	81.9	503.4	523.4	651.4	2261.3
1972	92.8	46.0	50.5	189.8	136.1	83.8	19.2	23.5	168.3	388.9	423.8	194.5	1817.2
1973	67.7	29.0	94.2	25.5	204.6	33.5	148.8	77.4	175.6	592.6	641.6	548.5	2639.0
1974	19.2	22.6	12.2	167.8	213.9	68.9	141.0	36.2	228.9	209.5	654.9	838.4	2613.5
1975	1239.5	158.5	44.7	34.5	317.0	97.4	99.7	110.6	270.1	335.5	616.9	266.2	3590.6
1976	37.5	0.1	8.5	149.4	159.7	66.0	177.7	104.3	105.7	316.3	1117.1	108.9	2351.2
1977	255.1	49.9	68.6	0.0	93.4	117.5	97.6	71.5	180.3	401.2	716.4	386.3	2437.8
1978	145.4	1.3	3.1	196.2	131.0	28.0	57.2	56.0	86.5	178.9	400.8	390.8	1675.2
1979	48.5	20.4	1.9	131.7	133.0	203.7	128.8	129.5	122.1	115.5	617.0	190.0	1842.1
1980	39.8	0.5	16.1	47.2	88.7	106.6	102.9	108.9	140.0	210.9	942.2	267.3	2071.1
1981	42.9	22.7	0.0	193.6	237.5	64.4	53.1	138.7	224.3	290.7	389.1	536.8	2193.8
1982	5.6	20.4	167.3	197.9	84.9	63.1	57.0	222.2	137.7	373.3	423.1	162.0	1912.1
1983	161.6	0.0	19.1	3.0	138.0	193.8	129.4	80.1	164.1	222.5	352.1	507.1	1970.8
1984	192.9	96.7	29.1	94.3	208.8	113.0	225.4	36.6	168.3	291.6	904.4	436.9	2798.0
1985	46.6	50.9	88.2	117.2	182.4	111.6	137.9	34.3	247.8	260.3	558.1	559.6	2394.9
1986	56.5	4.1	10.7	43.2	328.7	156.4	87.9	55.6	220.2	477.7	617.5	229.7	2288.2
1987	126.8	2.7	4.5	28.2	154.7	75.5	70.2	253.8	193.8	212.5	346.5	838.1	2377.3

Source : Meteorological Department

Table A1-1-6 : Monthly Rainfall at Kri Rat Nokom

Code; RM
Station; Amphur Kri Rat Nikom, Nakorn Sri Thammarat

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1956	0.0	0.0	26.3	185.7	150.1	197.3	85.6	226.0	119.0	184.5	100.7		1275.2
1957	0.0	0.0	12.3	112.5	54.9	61.1	40.8	0.0	75.4	80.8	72.2	0.0	510.0
1958	0.0	0.0	85.5	20.3	93.2	33.2	95.0	115.9	63.5	70.3	181.6	0.0	758.5
1959	73.5	0.0	101.0	15.7	190.2	0.0	159.3	58.5	13.7	132.3	273.8	109.8	1127.8
1960	0.0	5.0	36.6	62.4	216.3	8.2	214.5	61.3	58.4	238.6	33.1	0.0	934.4
1961	0.0	96.3	41.5	29.6	178.4	100.7	51.6	0.0	15.3	46.7	23.9	0.0	584.0
1962	0.0	0.0	0.0	65.9	146.7	52.6	32.7	0.0	44.8	196.2	69.4	0.0	608.3
1963	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	321.5	26.0	26.0	0.0	373.5
1964	0.0	0.0	0.0	0.0	26.0	0.0	18.0	159.0	0.0	15.0	70.0	87.5	375.5
1965	-	-	-										-
1966	37.3	-	-										37.3
1967	3.2	0.0	0.0	85.5	196.7	17.2	57.3	20.5	3.0	180.9	175.3	32.7	772.3
1968	33.2	0.0	0.0	100.2	120.7	164.7	47.1	22.5	0.0	153.1	18.4	8.5	668.4
1969	0.0	0.0	10.0	0.0	58.3	0.0	19.0	28.2	165.5	46.9	79.1	54.7	461.7
1970	3.5	0.0	0.0	26.5									30.0
1971	3.5	0.0	55.3	0.0	11.7	102.8	0.0	73.5	138.4	239.0	60.6		684.8
1972	0.0	28.5	0.0	61.7	16.2	76.4	94.1	23.6	101.8	64.9	183.1	51.0	701.3
1973	8.3	0.0	12.5	36.1	190.8	115.4	180.7	163.5	109.3	325.3	328.2	183.4	1653.5
1974	-	11.8	0.0	70.6	246.1	137.5	-	115.3	-	-	589.6	-	1170.9
1975	-	-	-	-	-	-	-		-	-	-	-	-
1976	4.3	0.0	20.3	207.4	195.0	110.0	60.3	60.1	119.4	159.8	386.3	17.4	1340.3
1977	27.7	11.2	5.5	75.6	123.8	108.8	99.2	202.9	122.7	170.6	659.0	52.1	1659.1
1978	-	-	-	-	-	-	-	-	70.2	110.4	50.6	206.0	437.2
1979	10.3	1.0	0.0	139.4	98.3	69.7	350.7	112.3	459.3	201.7	385.1	111.0	1938.8
1980	0.0	0.0	82.3	242.7	232.6	213.1	438.0	215.4	221.3	449.4	503.6	11.5	2609.9
1981	0.0	0.0	0.0	157.3	290.4	92.3	12.0	52.2	99.8	-	-	-	704.0
1982	0.0	0.0	100.1	169.0	102.6	70.7	108.5	133.6	153.2	90.9	176.0	42.5	1147.1
1983	17.1	0.0	44.3	0.0	324.7	175.6	97.2	124.0	250.5	88.3	119.6	81.1	1322.4
1984	42.8	24.6	83.5	129.5	135.1	126.0	100.2	97.1	183.1	63.4	49.0	21.8	1056.1
1985	19.4	66.6	92.4	148.2	116.9	122.6	24.8	133.0	70.6	123.6	140.0	37.6	1095.7

Source : Meteorological Department

Table A1-1-7 : Meteorological Data at Thung Song

Station : Nakhon Si Thummarat
Latituds : 08 28' N.
Longtitude : 99 58' E.
Elevation of station above MSL 7 meters

Items	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Temperature (C.degree)													
Mean	26.0	26.8	27.9	28.7	28.5	28.4	28.0	28.0	27.6	27.0	26.2	25.9	27.4
Mean Max.	29.7	31.1	32.7	33.7	33.5	33.3	33.1	33.2	32.7	31.3	29.5	29.1	31.9
Mean Min.	21.7	21.7	22.2	23.2	23.8	23.7	23.2	23.2	23.1	22.9	22.8	22.5	22.8
Ext. Max.	33.6	35.4	38.0	37.6	37.3	37.7	36.5	37.6	36.6	35.8	34.2	32.6	38.0
Ext. Min.	17.2	17.2	17.8	18.6	20.2	20.6	19.4	19.5	19.4	20.2	18.0	19.5	17.2
Relative Humidity (%)													
Mean	82.6	80.1	78.2	78.8	79.9	76.9	77.3	76.5	79.6	84.1	86.3	85.2	80.5
Mean Max.	95.6	95.5	95.1	94.9	94.3	92.5	93.2	92.4	94.4	95.9	95.9	95.4	94.6
Mean Min.	65.5	60.6	56.7	57.0	59.7	57.3	56.2	56.4	58.9	66.5	73.1	71.5	61.7
Ext. Min.	42.0	36.0	30.0	37.0	37.0	34.0	37.0	27.0	38.0	39.0	46.0	50.0	27.0
Evaporation (mm.)													
Mean - Pan	97.1	115.7	134.4	135.8	125.7	131.4	134.4	142.7	112.2	103.1	81.1	92.6	1406.2
Sunshine Duration (hr.)													
Mean	No Observation												
Wind (knots)													
Prevailing Wind	E	E	E	E	SW	SW	SW	SW	SW	SW	N	N	-
Mean Wind Speed	3.0	3.3	3.2	2.8	3.0	4.2	3.9	4.2	3.0	2.2	2.4	2.8	-
Max. Wind Speed	40 E	30 E	32 SW	50 S	44 WNW	40 SW, NWN	35 SW, WSW	55 WSW	47 SW	50 NW	52 E	30 E	55 WSW
Rainfall (mm.)													
Mean	170.5	46.3	48.2	98.4	170.7	93.0	109.7	96.6	155.6	344.5	610.3	438.7	2382.4
Mean Rainy Days	13.0	5.8	4.4	8.7	16.6	13.3	14.3	14.6	17.4	20.9	22.4	20.5	171.9
Greatest in 24 hr.	433.3	102.3	70.1	102.8	87.0	76.6	70.0	84.2	83.5	271.7	414.0	237.7	433.3
Day / Year	5/75	10/75	25/65	12/61	5/60	18/83	7/76	15/65	5/61	21/63	23/76	5/66	5/75

Source : Meteorological Department
Remark : Evaporation 1981-1985

APPENDIX A-2-1

Hydrological Data

Hydrological Data

Table A2-2-1 : Monthly Flow Records at Khlong Sao Thong

River : Khlong Sao Thong Location : Bang Wang Pha Station : 15 Drainage Area : 50 sq m

Year	Streamflow in (MCM)												Annual
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
1956	-	0.375	4.406	4.875	7.017	8.217	14.383	10.057	15.106	6.321	3.583	3.268	77.608
1957	2.773	2.866	2.618	4.794	3.990	5.236	8.089	13.193	21.856	6.294	3.048	2.008	76.765
1958	1.555	1.580	2.618	2.008	3.509	4.018	8.759	35.251	20.195	13.660	2.371	3.348	98.872
1959	1.970	2.303	2.100	4.419	5.276	3.189	10.526	19.232	22.097	9.080	-	-	80.192

Table A2-2-2 : Monthly Flow Records at Khlong Ban Tan

River : Huai Ban Tan Location : Bang Wang Khlo Station : 70 Drainage Area : 39 sq m

Year	Streamflow in (MCM)												Annual
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
1967	2.748	2.920	1.840	1.500	1.367	1.244	5.437	14.722	12.910	2.652	1.621	1.420	50.381
1968	0.959	1.098	0.881	0.643	0.643	0.493	4.660	7.128	11.999	7.339	2.856	2.571	41.270
1969	1.374	1.125	0.700	0.670	1.366	1.426	2.303	19.829	16.124	12.374	2.976	1.795	62.062
1970	3.888	0.005	3.551	1.821	1.848	1.711	3.669	21.203	14.704	5.518	2.976	3.509	69.246
1971	0.544	0.670	0.622	0.214	0.115	0.122	4.420	16.356	52.229	5.490	1.669	0.563	83.014
1972	5.029	2.555	1.877	1.310	0.937	2.644	6.375	11.534	10.660	2.207	1.213	0.980	47.321
1973	1.128	2.866	3.136	3.107	0.702	0.174	4.328	21.493	23.168	3.348	1.698	1.559	66.707
1974	1.397	2.437	1.592	1.310	2.033	1.840	2.705	18.701	31.525	-	7.911	6.509	77.960
1975	4.562	5.223	4.536	5.625	6.267	6.765	8.785	20.762	13.044	4.625	3.290	2.571	87.055
1976	2.359	4.473	4.692	2.759	-	-	7.339	31.104	13.740	13.338	4.134	4.741	88.679
1977	2.359	2.223	2.177	1.687	1.714	2.281	5.893	34.474	12.615	7.500	3.726	2.705	79.354
1978	3.396	3.884	2.437	0.254	2.170	-	4.018	10.290	18.294	5.250	2.540	1.956	54.489
1979	1.711	2.062	2.100	3.080	2.303	1.996	4.687	32.089	10.553	4.285	2.081	1.982	68.929
1980	1.763	1.661	1.659	1.661	1.821	2.022	4.071	21.695	15.776	5.196	3.157	2.223	62.705

Table A2-2-3 : Monthly Flow Records at Ban Khun Thale

River : Khlong Sao Thong Location : Lan Saka Station : 41 Drainege Area : 149sq.km

Streamflow in (MCM)

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
1967	9.098	13.767	9.279	10.108	13.686	8.139	21.829	71.280	60.531	11.222	5.128	3.509	237.576
1968	3.006	5.999	4.095	4.258	7.982	5.210	11.897	31.104	43.390	30.533	10.172	6.562	164.208
1969	5.754	4.660	4.380	4.955	3.830	10.757	10.311	24.676	31.605	44.997	12.434	7.312	165.671

Table A2-2-4 : Monthly Flow Records at Ban So

River : Khlong Sao Thong Location : Lan Saka Station : 18A Drainege Area : 163sq.km

Streamflow in (MCM)

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
1962	5.041	9.910	4.026	5.141	4.834	7.258	21.375	24.943	25.937	44.323	11.232	5.802	169.822
1963	5.785	3.736	5.882	5.447	5.008	14.583	53.881	69.552	58.906	58.570	18.063	9.631	289.044
1964	7.944	18.207	10.372	9.452	8.745	7.557	8.827	15.521	80.291	15.675	8.332	6.311	197.234
1965	11.664	27.475	18.230	18.403	11.577	10.886	24.970	68.947	13.323	47.001	15.120	11.405	398.903