4.3 Service Area and Served Population

4.3.1 Service Area

The present service area of the Phang Nga Waterworks consists of the Municipality of Phang Nga, its surrounding area and the Phang Nga Bay Resort Hotel.

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, population growth and tourism prospect.

The area was classified into three categories according to the DTCP's plan : (1) the high density area, (2) the medium density area, and (3) the low density area. The population and the service ratio are predicted by this classification.

The extent of the service area in years 2001 and 2011 are 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 0.962 (see Table 4-4-3), this ratio is applied to each year's 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.

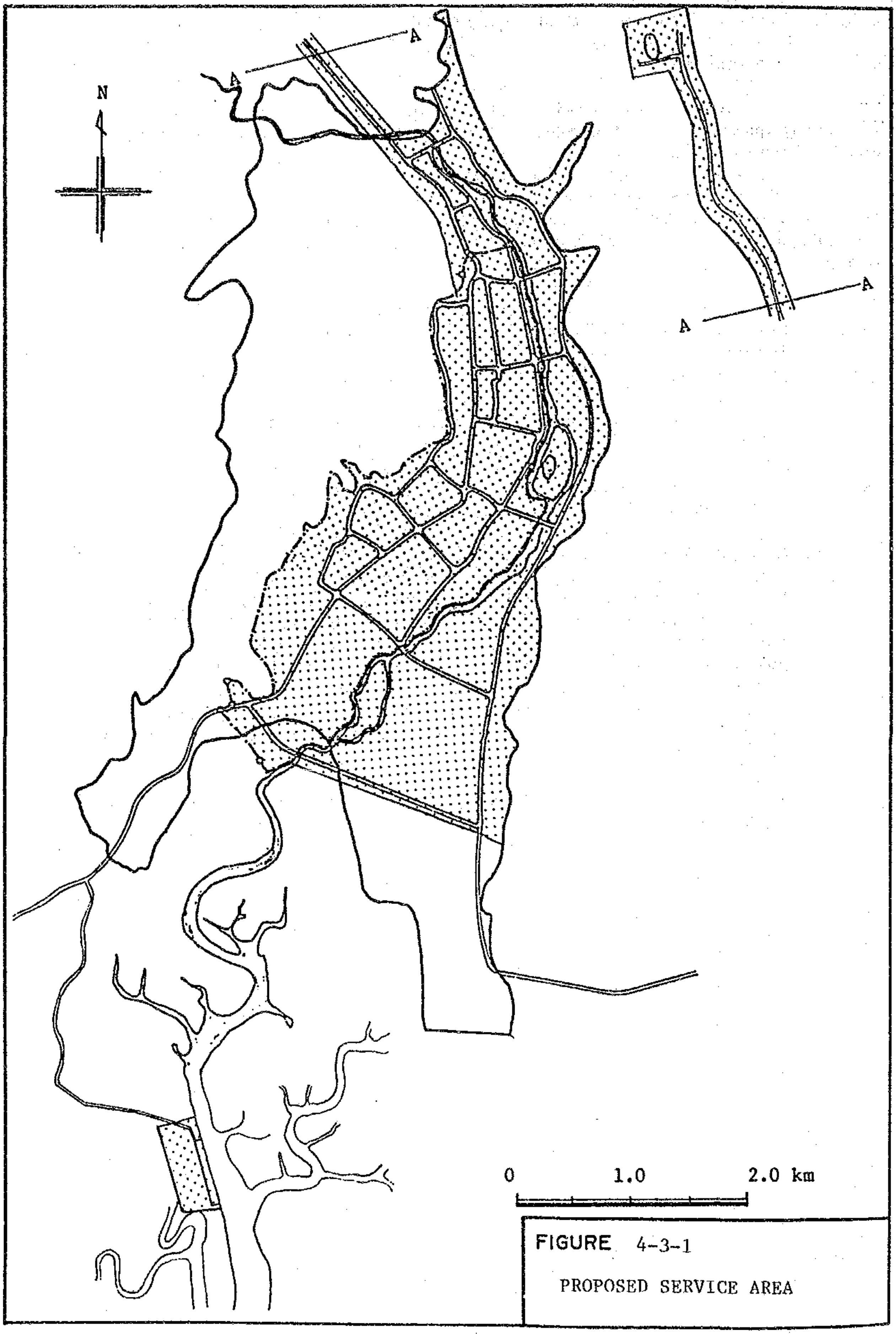


FIGURE 4-3-1

PROPOSED SERVICE AREA

Table 4-3-1 Estimation of Served Population

Year	No. of Conn. (a)	No. of Conn. for Domestic Use (b)	Pop./ No. of Houses (c)	Population Served (d)
1980	728	700	5.85	4,095
1981	839	807	5.52	4,455
1982	887	853	5.45	4,649
1983	928	893	4.27	3,813
1984	948	912	4.28	3,903
1985	979	942	4.20	3,956
1986	1,019	980	4.13	4,047
1987	1,041	1,001	3.96	3,964

(b) = (a) x 0.962
(c) = from Table 4-2-2
(d) = (b) x (c)

(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 (a)	Population Served (b)	Service Ratio (%) (c)
1980	7,640	4,095	53.60
1981	7,807	4,455	57.06
1982	7,939	4,649	58.56
1983	8,592	3,813	44.38
1984	8,791	3,903	44.40
1985	8,908	3,956	44.41
1986	8,886	4,047	45.54
1987	8,714	3,964	45.49

(a) from Table 4-2-1
(b) from Table 4-3-1

(3) Future Service Ratio Forecasting

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

Table 4-3-3 Future Service Ratio

(Unit : %)

Year	High Density Area	Medium Density Area	Low Density Area
1991	50	50	15
1996	56	56	30
2001	63	63	40
2006	69	69	55
2011	75	75	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	Population in Service Area by Density				Average Service Ratio (%)
	High	Medium	Low	Total	
1991	1,025	2,361	595	3,981	37.1
	(2,050)	(4,722)	(3,965)	(10,737)	
1996	1,226	2,959	1,302	5,487	46.4
	(2,190)	(5,284)	(4,340)	(11,814)	
2001	1,473	3,724	1,900	7,097	54.6
	(2,338)	(5,911)	(4,750)	(12,999)	
2006	1,773	4,698	2,943	9,414	63.9
	(2,570)	(6,808)	(5,351)	(14,729)	
2011	2,010	5,576	4,002	11,588	73.2
	(2,680)	(7,435)	(5,717)	(15,832)	

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

(5) Prediction of Number of Tourists

The study on Potential Tourism Area Development for Southern Region in Thailand for TAT by JICA predicts the number of hotel rooms and tourists.

The study defines the three types of accommodation: higher, lower and in-town class hotels. These three types are assumed to have different pattern of water use because of the level of facilities and equipment. the breakdown of the number of rooms for each type are shown in Table 4-3-5.

Table 4-3-5 Prediction of Number of Hotel Rooms

Year	High	Low	In-Town	Total
1991	90	56	403	549
1996	90	56	403	549
2001	415	81	403	899
2006	415	81	403	899
2011	415	81	403	899

The number of tourists is predicted by assuming the occupancy ratio and average number of guests per hotel room. These figure are:

Occupancy ratio = 75 %

Number of guests per room = 1.6 persons

The total number of tourists of stay is, therefore calculated as follows:

Table 4-3-6 Number of tourists of Stay

(Unit: pers./d)

Year	High	Low	In-Town	Total
1991	108	67	484	659
1996	108	67	484	659
2001	498	97	484	1,079
2006	498	97	484	1,079
2011	498	97	484	1,079

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	316,620	269,411	728	1.011
1981	335,250	302,290	839	0.987
1982	350,480	308,494	887	0.953
1983	391,300	299,746	928	0.885
1984	394,210	283,746	948	0.818
1985	398,670	314,959	979	0.881
1986	421,970	287,428	1,019	0.773
1987	442,340	267,121	1,041	0.703

(2) Classification of Consumption

PWA Survey Reports on 1987 shows the consumption by categorized major consumer as listed in Table 4-4-2. Table 4-4-3 shows the share of each group after being regrouped into six groups for convenience of estimating the future water demand.

4.4.2 Future water consumption

The six 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 domestic water consumption is accounted to be 56.8% of the total in 1987. Assuming that this ratio has been constant from 1980 to 1987, the domestic water consumption is calculated as shown in Table 4-4-4.

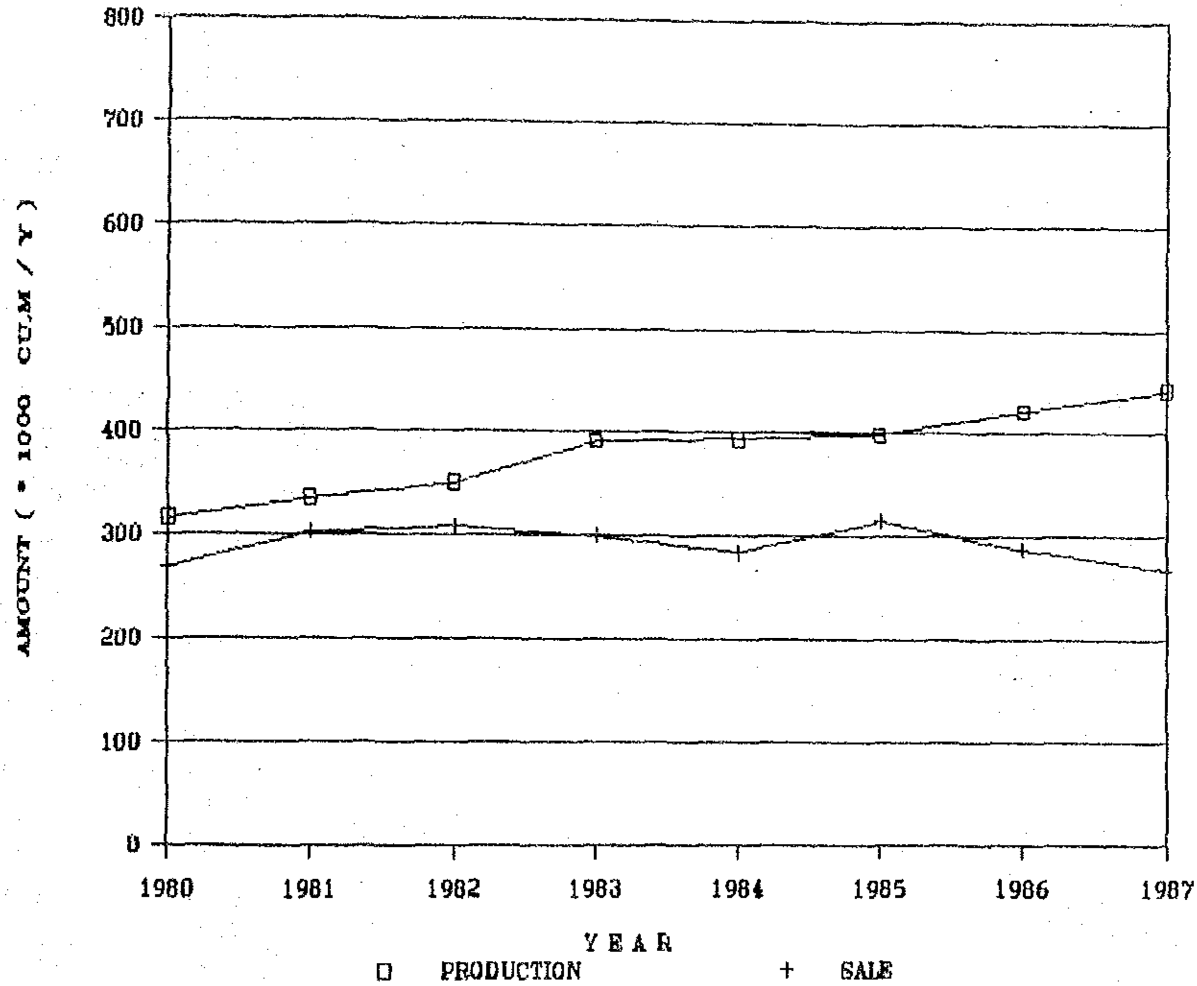


FIGURE 4-4-1

WATER PRODUCTION/SALE
PHANG NGA

Table 4-4-2 Water Consumption by Category in Phang Nga

Code	Category	1987 No.of Conn.	1987 Consump.	Share No.of Conn.	Share Consump.
1	Residential	3	72	0.29	0.32
2	Residential(Rental)			0.00	0.00
3	Commercial	5	279	0.48	1.26
4	Restaurant	1	45	0.10	0.20
5	Governmental Agency	22	3775	2.11	16.99
6	School	6	1086	0.58	4.89
7	Temple	1	92	0.10	0.41
8	Bangalow			0.00	0.00
9	Industrial	1	329	0.10	1.48
10	Hotel	4	3999	0.38	18.00
11	Hospital			0.00	0.00
12	Service			0.00	0.00
13	Others			0.00	0.00
	Sub-Total	43	9677	4.14	43.55
	Percentage	4.13	43.56		
14	Other than Major Consumer	998	12538	95.87	56.44
	Sub-Total	998	12538	95.87	56.44
	Percentage	95.87	56.44		
	Total	1041	22215		
	Percentage	100	100	100	100

Table 4-4-3 Water Consumption by Category in Phang Nga (After Re-grouping)

Code	Category	1987 No.of Conn.	1987 Consump.	Share No.of Conn.	Share Consump.
	Domestic				
1	Residential	3	72	0.29	0.32
14	Other than Major Consumer	998	12538	95.87	56.44
	Sub-Total	1001	12610	96.16	56.76
	Institutional				
5	Governmental Agency	22	3775	2.11	16.99
6	School	6	1086	0.58	4.89
7	Temple	1	92	0.10	0.41
11	Hospital			0.00	0.00
	Sub-Total	29	4953	2.79	22.30
	Tourism				
8	Bangalow			0.00	0.00
10	Hotel	4	3999	0.38	18.00
	Sub-Total	4	3999	0.38	18.00
	Commercial				
3	Commercial	5	279	0.48	1.26
4	Restaurant	1	45	0.10	0.20
	Sub-Total	6	324	0.58	1.46
	Industrial				
9	Industrial	1	329	0.10	1.48
	Sub-Total	1	329	0.10	1.48
	Others				
12	Service			0.00	0.00
2	Residential(Rental)			0.00	0.00
13	Others			0.00	0.00
	Sub-Total	0	0	0.00	0.00
	Total	1041	22215	100.00	100.00

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	269,411	736	418	4,095	102
1981	302,290	828	470	4,455	105
1982	308,494	845	480	4,649	103
1983	299,746	821	466	3,813	122
1984	283,746	775	440	3,903	113
1985	314,959	863	490	3,956	124
1986	287,428	787	447	4,047	110
1987	267,121	732	416	3,964	105

(c) = (a) x 0.568

The estimated per capita consumption for 1991 is 120 lpcd in the high density area. Considering the socioeconomic feature of Phang Nga and living standard, an arithmetical progression curve which comes up to 140 lpcd in 2011 is selected.

For the medium and low density areas, the per capita consumptions in 2011 are assumed to be 140 lpcd and 100 lpcd, respectively.

Table 4-4-5 summarizes the unit water consumption by area.

Table 4-4-5 Unit Water Consumption by Area

(Unit : lpcd)

Year	High	Medium	Low
1991	120	120	-
1996	125	125	70
2001	130	130	80
2006	135	135	90
2011	140	140	100

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	High & Medium	Low	Total
1991	410	-	410
1996	523	91	614
2001	676	152	828
2006	874	265	1,139
2011	1,062	400	1,462

(2) Governmental/Institutional Water Consumption

The governmental/institutional water consumption includes the consumption of such institutions as governmental 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, the future water consumption of the governmental facilities is predicted from the ratio to the population in the service area of each year. The present data gives the following figures for the water consumption of governmental offices.

Total consumption of governmental offices (1987)

$$Q = 3,775 \text{ cu.m/mo}$$

Population in the service area (1987)

$$p = 10,740$$

The average daily consumption of governmental offices expressed by per population is:

$$q = Q/p = 3,775 /30/10,740 = 11.7 \text{ lpcd}$$

For future unit consumption, 10 lpcd is adopted.

(b) School

Prediction of the water consumption of schools 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. In 1987 the per student consumption is given as below:

Total consumption of schools (1987)

$$Q = 1{,}086 \text{ cu.m/mo (from Table 4-4-2)}$$

Number of students in Amphoe Phang Nga (1987)

$$n = 3{,}709 \text{ (from Table 1-2-2)}$$

The per student daily average consumption is:

$$q = Q/p = 1{,}086 \;/\; 30 \;/\; 3{,}709 = 3.8 \text{ lpcd}$$

Considering that only a part of student in Amphoe Phang Nga is studying in the schools in the service area, the unit consumption in the future is set at 20 lpcd.

The number of students is assumed to increase along with the population in the service area with the same proportion as that in 1987.

(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 the 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	882
1986	744	354	862
1991			(700)
2006			(600)

The ratio of population to bed in the whole of the province was 572.90 in 1985 already less than a national target of 600 in 2006. Therefore the number of beds is assumed to be same as it is in 2011.

Assuming a water consumption per bed to be 1.5 cu.m/d through years, the total consumption of hospital 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	1987	1991	1996	2001	2006	2011
1. Government						
o per pop. consump. (lpcd)	11.7	10	10	10	10	10
o population in service area		10,737	11,814	12,999	14,729	15,832
o consump. (cu.m/d)	126	107	118	130	147	158
2. School						
o per student consump. (lpcd)	9.8	20	20	20	20	20
o No. of students		1,652	1,818	2,000	2,266	2,436
o consump. (cu.m/d)	36	33	36	40	45	49
3. Hospital						
o per bed consump. (cu.m/d/bed)		1.5	1.5	1.5	1.5	1.5
o No. of beds		164	164	164	164	164
o consump. (cu.m/d)	-	246	246	246	246	246
Total consump. (cu.m/d)	162	386	400	416	438	453

(3) Tourism Water Consumption

The tourism water consumption is defined as the water required by hotels and other accommodations.

The tourism water consumption is estimated by multiplying per capita consumption by the number of tourists.

Water consumption of hotels in 1987 is 3,999 cu.m/mo as shown in Table 4-4-2, while the average number of tourists is reportedly about 300.

Unit consumption = 3,999 / 300 = 444 lpcd

This figure (483 lpcd) is lower than the past record of Pattaya (622 lpcd in 1982) and the planned per capita consumption of Chiang Mai (700 lpcd in 1987 Report).

However, the value for planning for Phuket Water Supply Development Plan (640 lpcd for high-class, 500 lpcd for low-class and 395 lpcd for in-town hotels in 2011) is adopted for the per capita consumption of tourist in Phang Nga considering that the tourists are coming from Phuket.

The total consumption by tourists is, therefore calculated from the number of tourists and per capita consumption as shown below:

Table 4-4-9 Tourism Consumption

Year	No. of Tourists (pers./d)			Consumption (cu.m/d)			
	High (a)	Low (b)	In-Town (c)	High (d)	Low (e)	In-Town (f)	Total
1991	108	67	484	69	34	191	294
1996	108	67	484	69	34	191	294
2001	498	97	484	319	49	191	559
2006	498	97	484	319	49	191	559
2011	498	97	484	319	49	191	559

(d) = (a) x 640 lpcd
(e) = (b) x 500 lpcd
(f) = (c) x 395 lpcd

(4) Commercial Water Consumption

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

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

324 / 30 / 8.714 = 1.2 lpcd

For future consumption, 10 lpcd is adopted. Commercial consumption in the future is therefore calculated as shown in Table 4-4-10.

Table 4-4-10 Commercial Consumption

Year	Total Population in Service Area	Unit Consump. (lpcd)	Commercial Consump. (cu.m/d)
1991	10,737	10	107
1996	11,814	10	118
2001	12,999	10	130
2006	14,729	10	147
2011	15,832	10	158

(5) Industrial Water Consumption

Past data shows that industrial water consumption is 1.9% to the total of domestic and institutional consumption.

There is no sign that the water use for this purpose would increase in the future. Therefore, this rate is assumed to be low in the future. A fixed ratio of 1.9% to the total of domestic and institutional consumption is adopted for the future unit consumption for industrial use as shown below:

Table 4-4-11 Industrial Consumption

(Unit : cu.m/d)

Year	Domestic & Institutional (a)	Industrial (b)
1991	796	15
1996	1,014	19
2001	1,244	24
2006	1,577	30
2011	1,915	36

(b) = (a) x 0.019

(6) Unaccounted-for Water Ratio

Unaccounted-for water ratio of the Phang Nga Waterworks has been increasing as shown in Table 4-4-12. Improvement works have to be implemented to reduce this ratio.

This ratio is supposed to be improved as much as possible by investing for the improvement works such as replacement of old pipes, leakage detection, and replacement of water meters with the more sensitive and anti-reverse rotation type.

Table 4-4-12 Unaccounted-for Water Ratio

Year	Water Production (cu.m/y)	Water Sales (cu.m/y)	Unaccounted-for Water Ratio (%)
1980	316,620	269,411	14.91
1981	335,250	302,290	9.83
1982	350,480	308,494	11.98
1983	391,300	299,746	23.40
1984	394,210	283,746	28.02
1985	398,670	314,959	21.00
1986	421,970	287,428	31.88
1987	442,340	267,121	39.61

PWA set a target of reducing the unaccounted-for water as one of measures for cost recovery at 25 and 20 percent in 1995 and 2010, respectively. Implementing program of leakage controls presently on going at various waterworks under PWA.

However, it may be difficult for the Phang Nga Waterworks to catch up this PWA's target unless large amount of budget is secured for the improvement of the pipeline. Considering this constraints, future unaccounted-for water ratio is set as shown in Table 4-4-13.

Table 4-4-13 Future Unaccounted-for Water Ratio

(Unit : %)

Year	Unaccounted-for Water Ratio
1991	26
1996	25
2001	23
2006	21
2011	20

4.4.3 Future Water Demand

(1) Peak Factor

The data on daily water demand are available since July 11, 1988 when the master meter reading has started as the routine work. To supplement the data-lacked period, the monthly water distribution data were used for analysis. The results of analysis on the peak factor are summarized in Table 4-4-14.

Table 4-4-14 Peak factor

Item	Demand (cu.m/d)	Factor	Date
Daily Maximum	1,538	1.281	Feb. 5
Monthly Minimum	1,389	1.158	Feb.
Daily Average	1,200	1	
Monthly Maximum	1,141	0.870	May
Daily Minimum			

The monthly fluctuations during the data-lacked period are less than 0.900 which suggest that the daily maximum water demand is unlikely to occur in these months from the experience in the study of other areas.

A value of 1.30 is accordingly adopted for the peak factor.

(2) Future Water Demand

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

Table 4-4-15 shows the average and maximum daily water demand.

Table 4-4-15 Future Water Demand

(Unit : cu.m/d)

Category	1987	1991	1996	2001	2006	2011
Domestic	416	410	614	828	1,139	1,462
Gov'l/Inst'l	163	386	400	416	438	453
Tourism	131	294	294	559	559	559
Commercial	9	107	118	130	147	158
Industrial	11	15	19	24	30	36
Sub-Total	730	1,212	1,445	1,957	2,313	2,668
Unaccounted-for Water Ratio (%)	39.61	26	25	23	21	20
Unaccounted-for Water	479	426	482	585	615	667
Daily Average	1,209	1,638	1,927	2,542	2,928	3,335
Peak Factor	1.30	1.30	1.30	1.30	1.30	1.30
Daily Maximum		2,129	2,505	3,305	3,806	4,336

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

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 7,130 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 17.

Part 2
DEVELOPMENT PLAN

Part 2 DEVELOPMENT PLAN

7. CONSIDERATION FOR DEVELOPMENT PLAN

Expansion of the treatment plant capacity is the main subject in consideration for the development plan.

The treatment plant capacity is said to be increased so that it could almost meet the amount of water demand in 2011.

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 described 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
Weir Extension	Fair	Fair	Fair	Fair	Poor
Mining Pit Expansion	Fair	Good	Good	Good	Good
New Mining Pit	Fair	Good	Good	Good	Poor
Phang Nga River	Good	Good	Poor	Good	Good
New Transm'n Pipe	Fair	Fair	Fair	Fair	Fair
Dam	Good	Poor	Poor	Poor	Poor
Ground	Poor	Fair	Fair	Fair	Fair

(1) Dam Construction on the Khlong Tham

The dam construction is unrealistic due to the high construction cost and difficulty in land acquisition unless the dam has multi-purpose of water supply, irrigation and flood control.

(2) Ground Water Development

Ground water development is unreasonable for public water supply due to insufficiency.

(3) Enlargement of Existing Weir and Installation of Transmission Pipe

Water demand in the target year at the intake level is estimated at 4,800 cu.m/d, while the water supply capacity of the existing mining pit is 300 cu.m/d. The balance of 4,500 cu.m/d or 0.135 MCM/mo is accordingly newly required for water supply. Considering that 50% of water is used for irrigation, the monthly water requirement is 0.27 MCM.

The water balance study in the dry season shows that the storage required for existing weir is estimated at approximately 0.72 MCM.

This capacity is so large that the weir enlargement requires a large amount of investment for construction, detour road and land compensation.

Table 8-1-2 Water Balances in Dry Season

(Unit : MCM)

Year		Dec	Jan	Feb	Mar	Apr	May	Total
	D	0.270	0.270	0.270	0.270	0.270	0.270	
1973	S	enough	0.103	0.048	0.044	0.161	enough	
	B	-	0.167	0.222	0.226	0.109	-	0.724
	D	0.270	0.270	0.270	0.270	0.270	0.270	
1975	S	enough	0.252	0.161	0.128	0.113	enough	
	B	-	0.018	0.109	0.142	0.157	-	0.426
	D	0.270	0.270	0.270	0.270	0.270	0.270	
1976	S	enough	0.178	0.144	0.128	0.080	enough	
	B	-	0.092	0.126	0.142	0.190	-	0.550

Note : D Demand
S Supply
B Balance (= D-B)

(4) New Mining Pit Development

A few mining pits are located 2 km upstream of the existing pit. These pits are located so closely to the Phang Nga River that the pits become full of water in the rainy season by flooding. The required storage capacity is estimated by applying the same conditions as the existing pit.

$$3,900 \times 30 \times 7 \times 1.3 = 1,065,000 \text{ cu.m}$$

(5) Intake from the Phang Nga River and Expansion of the Existing Mining Pit

Since the Phang Nga River has sufficient flow even in the dry season, intake from the river is considered to be the most appropriate, if technical problems are solved by constructing a sedimentation basin near the pit.

(a) Available Amount of Water

As shown in Table 8-1-3, the minimum flow at the mining pit is estimated at 0.54 cu.m/s, while the water demand is 0.050 cu.m/s.

Raw water can be taken from the Phang Nga River into the mining pit, but a sedimentation basin is required before flowing into the pit to reduce a turbidity.

Table 8-1-3 Monthly Stream Flow at Mining Pit

(Unit : cu.m/s)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1972	-	-	-	-	-	-	-	-	42.3	15.3	11.7	4.9
1973	2.3	1.1	0.8	1.3	2.7	22.1	49.8	35.5	33.3	30.8	18.5	8.1
1974	4.7	3.4	2.7	3.9	16.7	34.5	21.4	94.0	35.2	54.2	39.4	7.6
1975	7.2	3.4	2.7	2.2	6.1	66.9	-	44.5	20.2	43.9	21.0	4.6
1976	2.4	1.5	1.6	2.3	27.2	25.2	43.5	30.6	66.9	10.1	9.5	4.6
1977	2.6	2.1	2.7	0.9	5.7	6.8	9.2	55.7	-	17.9	12.9	4.4
1978	2.7	1.9	2.1	1.8	7.6	39.5	51.4	79.6	71.8	36.2	0.3	4.6
1979	2.6	1.7	0.9	6.5	19.4	21.1	74.4	52.4	40.2	50.1	7.3	4.4
1980	3.0	2.3	2.4	2.9	7.4	24.0	58.7	59.6	66.2	39.9	24.7	11.8
1981	6.5	4.4	2.7	3.7	9.8	46.8	22.6	15.0	28.0	17.3	26.0	10.5
1982	5.9	3.8	2.9	5.7	9.9	14.8	66.8	51.1	49.4	22.8	14.9	9.1

Note : (287.5/312) / (No. of days in a month) / 86,400

The minimum flow is obtained by probability analysis using the monthly minimum flow in the return period of 1/10.

While,

Intake Amount = (4,800-600) / 86,400
= 0.049 cu.m/s < 0.54 cu.m/s

(b) Capacity Required for Sedimentation

Intake Amount : 0.049 cu.m/s 60 x 60 = 176 cu.m/h
Detention Time : 3 h
Capacity Required : 176 x 3 x 1.2 = 640 cu.m

In this way, seven alternatives can be integrated into three plans.

(1) Extension of existing weir and installation of transmission pipe
(2) New mining pit development
(3) Intake from the Phang Nga River and expansion of existing mining pit

Preliminary design and cost estimate for these three plans are described in Table 8-1-4.

Accordingly, from the view point of technical aspects, land acquisition and construction cost, intake from the Phang Nga River and expansion of the existing mining pit are the most appropriate plan for the Phang Nga water supply development.

Table 8-1-4 Development Plan

(Unit : X 1,000 B)

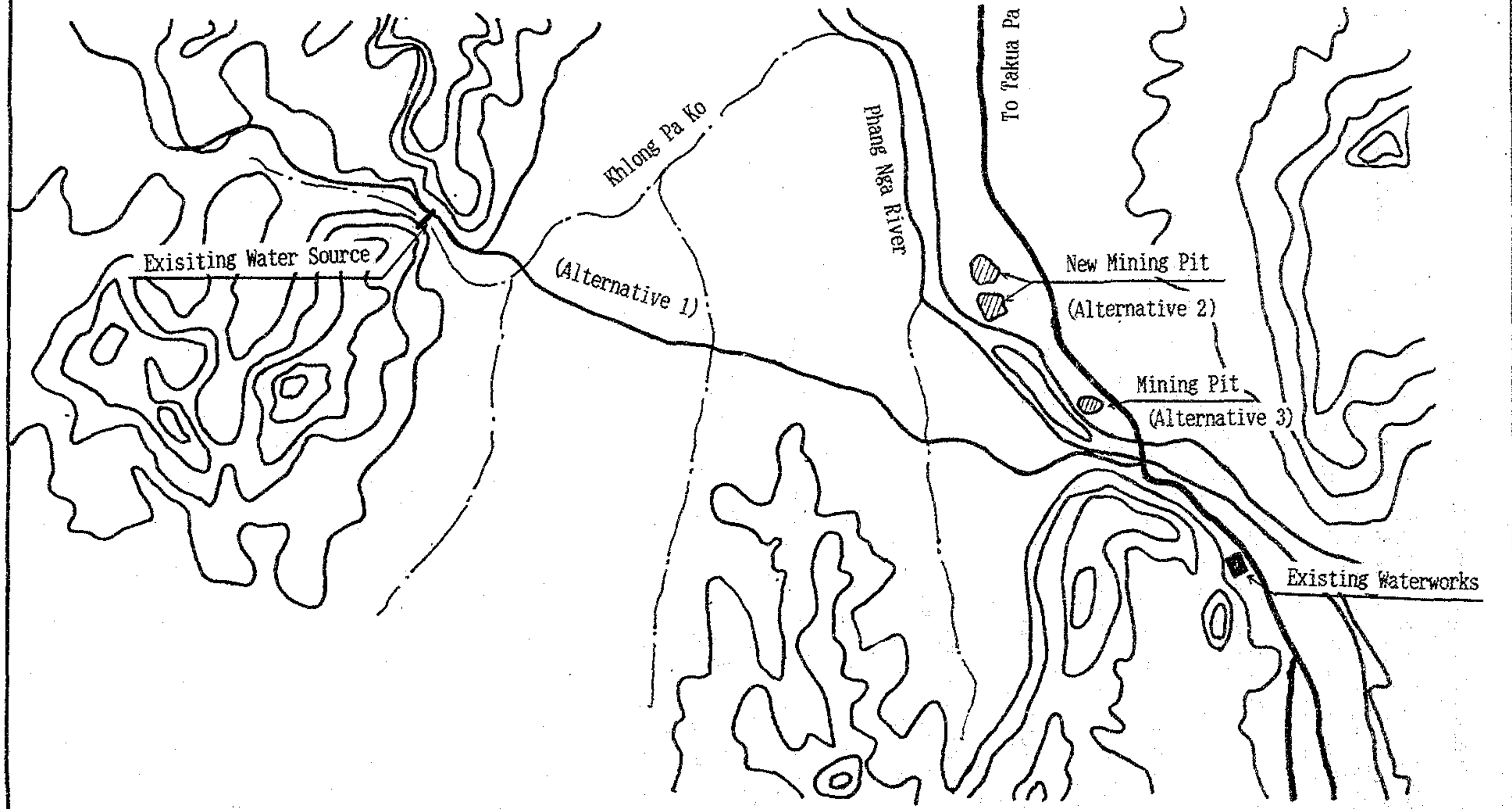
Facility	Dimensions/Specifications	Cost
(1) Extension of existing weir and installation of transmission pipe		
Concrete Weir	10.0 m high x 60.0 m long 600 cu.m in volume	3,300
Detour Road	4.0 m wide x 200 m long	600
Land Acquisition	5 ha	5,000
Transmission Pipe	AC 150 mm x 5.7 km long	3,300
	Total	12,200
(2) New mining pit development		
Land Acquisition	3 ha x 3 pits	9,000
Pumping Station	2.16 cu.m/min x 20 m x 5.5 kw x 6 units 80 mm	700
Transmission Pipe	AC 100 mm x 1.0 km long AC 200 mm x 2.0 km long	410 1,640
	Total	11,750
(3) Intake from the Phang Nga River and expansion of the existing mining pit		
Pump Station	2.16 cu.m/min x 10.0 m x 5.5 kw x 3 units 100 mm	350
Transmission Pipe	AC 300 mm x 250 m long	370
Sedimentation Basin	600 cu.m in volume	60
Pit Excavation	200 cu.m in volume	20
	Total	800

8.1.2 Water Source Development Plan

Water source development plan is shown in Figure 8.1.2, in which an intake pumping station will be constructed close to the Phang Nga River together with a sedimentation basin, two pumps and intake pipes by 1990. The remaining one pump will be installed by 1997.

Table 8-1-5 Water source Development Plan

Project	Year	Water Supply Capacity (cu.m/d)	Daily Maximum Water Demand (cu.m/d)
Phase I	1990	2,750	2,300
Pumping Station			
Pump 1.08 cu.m/min 100 mm x 5.5 kw x 2 units			
Sedimentation Basin			
Phase II	1997	4,300	3,993
Pump 1.08 cu.m/min 100 mm x 5.5 kw x 1 unit			



Note ; 1 Enlargement of the existing weir

2 New mining pit development

3 Intake from the Phang Nga river

Figure 8-1-1

Alternative Plans

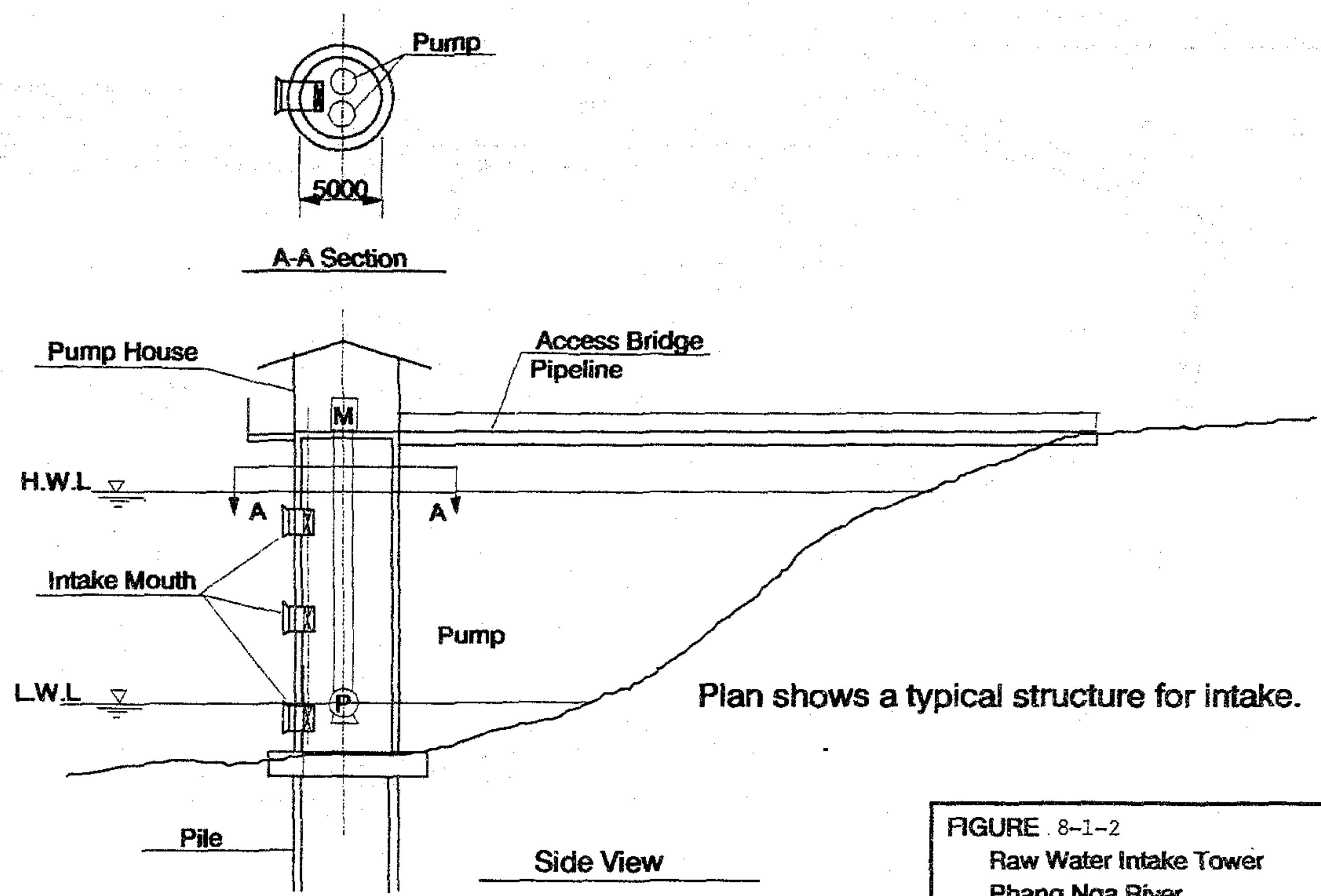


FIGURE . 8-1-2
Raw Water Intake Tower
Phang Nga River

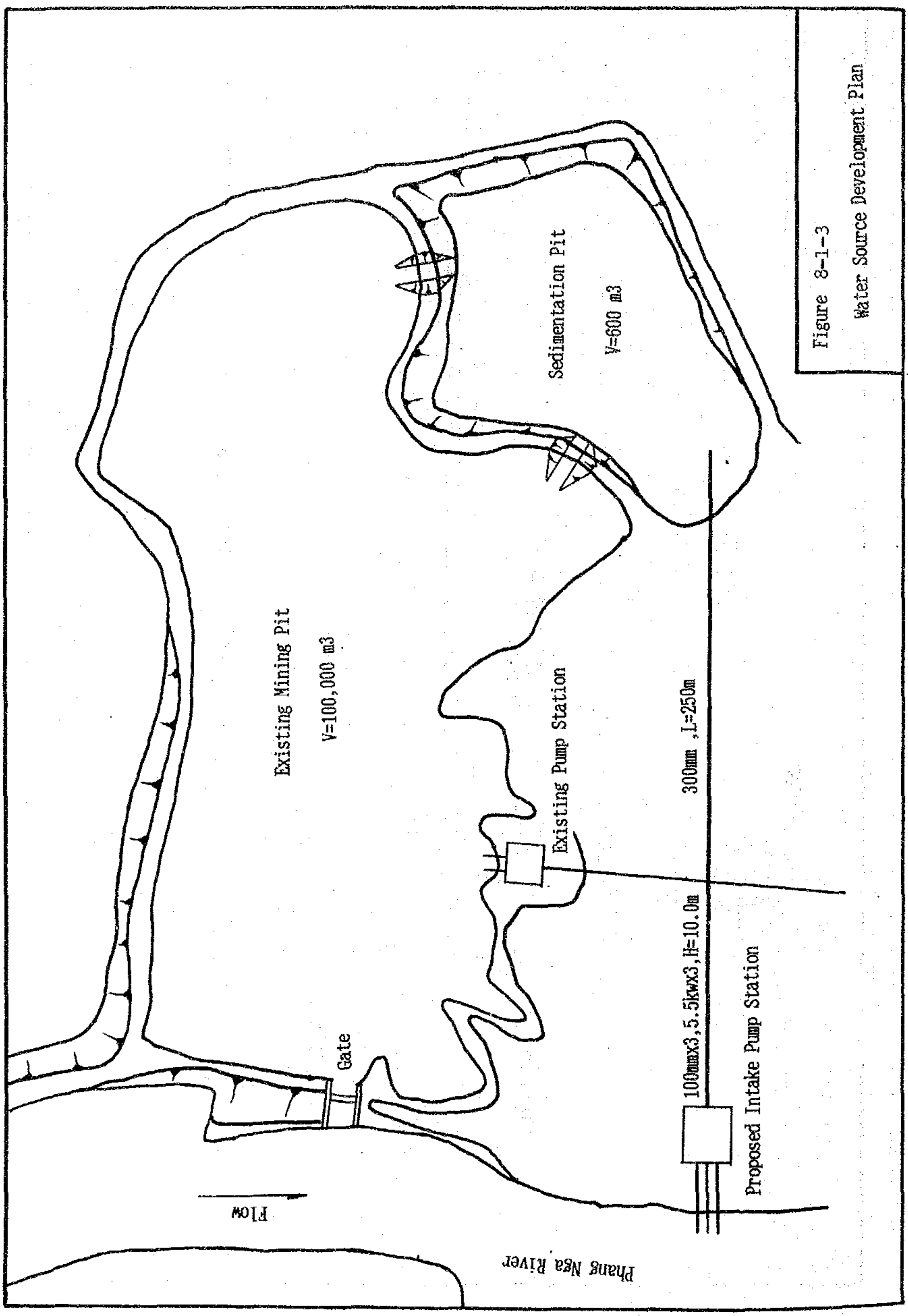


Figure 8-1-3
Water Source Development Plan

8.2 Water Supply System

8.2.1 Water Treatment Capacity

The existing treatment plant was originally designed to have a maximum treatment capacity of 60 cu m/h (or 1,440 cu m/day), consisting of the old and new units of 20 and 40 cu m/h, respectively.

The plant has then had a modification for increasing the capacity with means as follows:

Sedimentaion Basin	: Installation of the inclining plate
Sand Filter	: High rate filtration (10 to 12 m/h, or 240 to 288 m/day)

The treatment capacity was said to have increased to a total of 180 cu m/h (4,320 cu m/day). The modification works were designed by PWA on the basis of some experimental run at the plant. The operation after the modification has also been monitored and showed the good results. The good treatability may be derived from the clearness of the raw water taken from the waterfall although the rate of filtration is quite high.

It is difficult to evaluate the suitability of the increased capacity since the plant has started the operation just in January 1990. To evaluate the system, long run and accumurating the data will be necessary.

The projected water demand in 2011 is 4,336 cu m/day which is slightly higher than the modified plant capacity (4,320 cu m/day) so that the plant expansion may be needed in 2011 even though the plant could operate with the planned capacity.

Considering the conditions above, no expansion of the treatment plant is proposed in this report. Figure 8.2.1 shows a water demand prediction and the treatment plant capacity.

However, the expansion of the treatment plant, if necessary, is possible to be made in the existing plant site since there is a enough room for expansion in the plant.

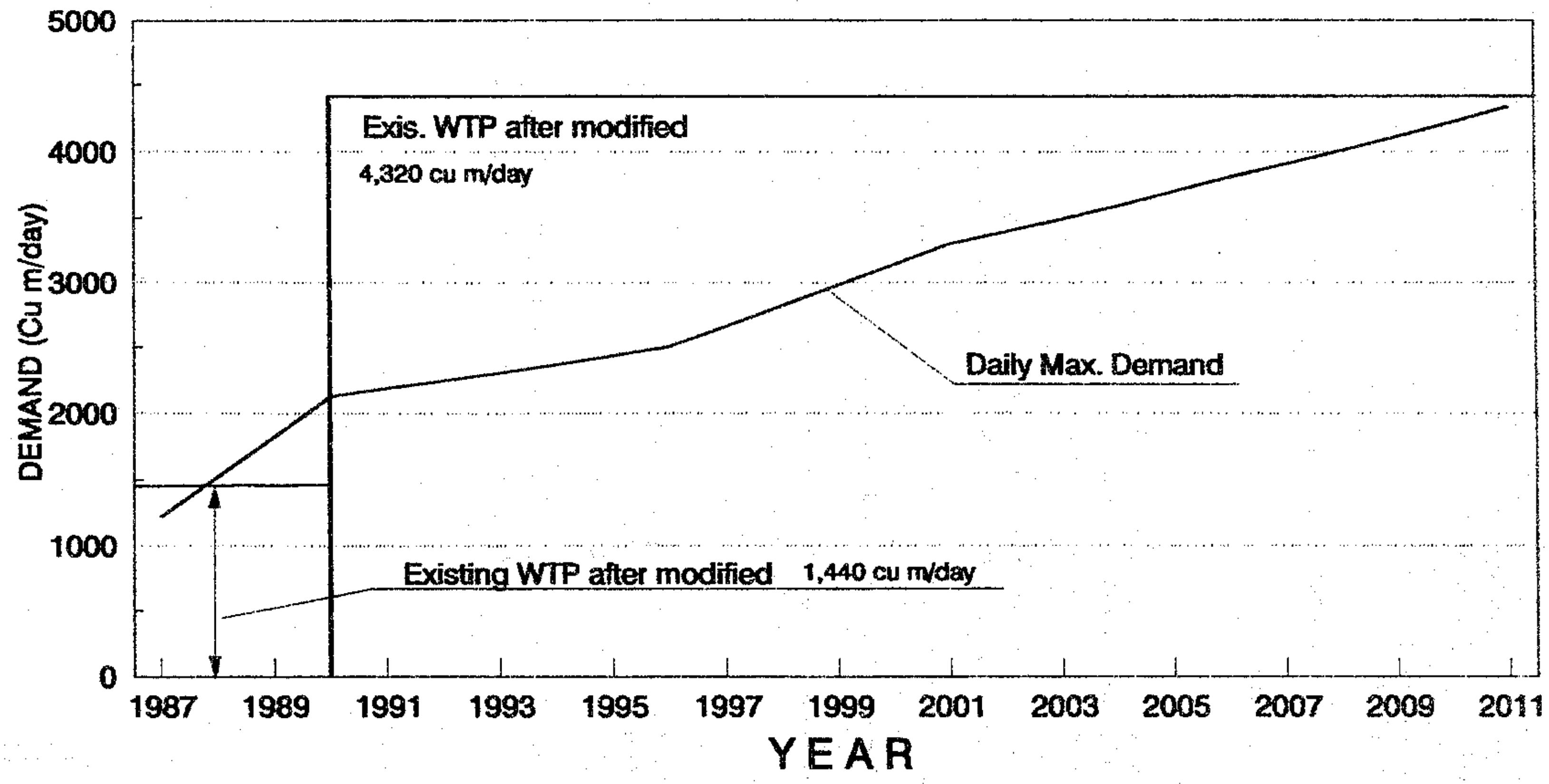


FIGURE 8-2-1
Water Treatment Plant
Capacity and Water Demand

8.2.2 Proposed Distribution System

The distribution system with a water demand in 2011 was analyzed to optimize the system. The minimum pressure in the houly maximum flow is set at 1.0kg/sq.cm for general application.

The proposed system includes installation of 21.3km long mains, ranging from 100mm to 150mm diameter. Based on the results of the distribution network analysis, distribution pipeline are sized to serve the maximum hourly flows with sufficient service pressure throughout the proposed system.

Replacement of the existing pipes is also recommeded for the pipes which has been aged and are of lower class of material. These pipes will be replaced with a new pipes of the same size. The pipes to be replaced are separated into three groupes according to their ages and locations. Table 8.2.1 tabulates the breakdown of pipes to be replaced.

A schematic plan for the its system are shown in Figure 8.2.3. The results of the distribution network analysis are presented in the separate volume.

Breakdown of the proposed distribution pipeline including a replacement of the existing pipeline system are tabulated in Table 8.2.2.

Table 8.2.1 Replacement of the Existing Pipes

Node No. From	To	Dia.(mm)	Length(m)	Type Class	Year of Installation
a) Group A					
100	1	200	550	AC,15	1962
4	29	150	60	AC,15	1962
4	5	200	240	AC,15	1962
5	7	200	160	AC,15	1962
29	31	100	250	AC,15	1962
31	33	100	180	AC,15	1962
33	35	150	115	AC,15	1962
35	37	150	180	AC,15	1962
37	39	150	90	AC,15	1962
39	41	150	110	AC,15	1962
41	43	150	230	AC,15	1962
43	44	150	80	AC,15	1962
44	45	150	675	AC,15	1962
45	9	100	20	AC,15	1962
b) Group B					
29	32	150	190	AC,15	1969
32	31	100	130	AC,15	1969
32	34	150	200	AC,15	1969
34	33	100	165	AC,15	1969
34	36	150	100	AC,15	1969
36	35	100	185	AC,15	1969
36	38	150	215	AC,15	1969
38	37	100	215	AC,15	1969
38	40	150	60	AC,15	1969
40	39	100	205	AC,15	1969
40	42	150	155	AC,15	1969
42	41	150	145	AC,15	1969
7	33	200	15	AC,15	1969
7	8	200	515	AC,15	1969
8	41	150	20	AC,15	1969
8	9	200	990	AC,15	1969
c) Group C					
9	21	150	610	AC,15	1969
21	22	150	710	AC,15	1969
22	24	150	380	AC,15	1969
14	16	100	130	AC,15	1969
16	17	100	240	AC,15	1969
16	24	100	290	AC,15	1969
17	19	100	270	AC,15	1969
19	25	100	20	AC,15	1969
19	20	100	170	AC,15	1969

Table 8.2.2 Proposed Distribution pipelines

Dia (mm)	Length (m)	Materials
(Replacement)		
a) Group A		
200	950	AC
150	1,540	AC
100	450	AC
b) Group B		
200	1,520	AC
150	1,085	AC
100	900	AC
c) Group C		
150	1,700	AC
100	1,120	AC
(New Pipes)		
150	200	AC
100	21,110	AC

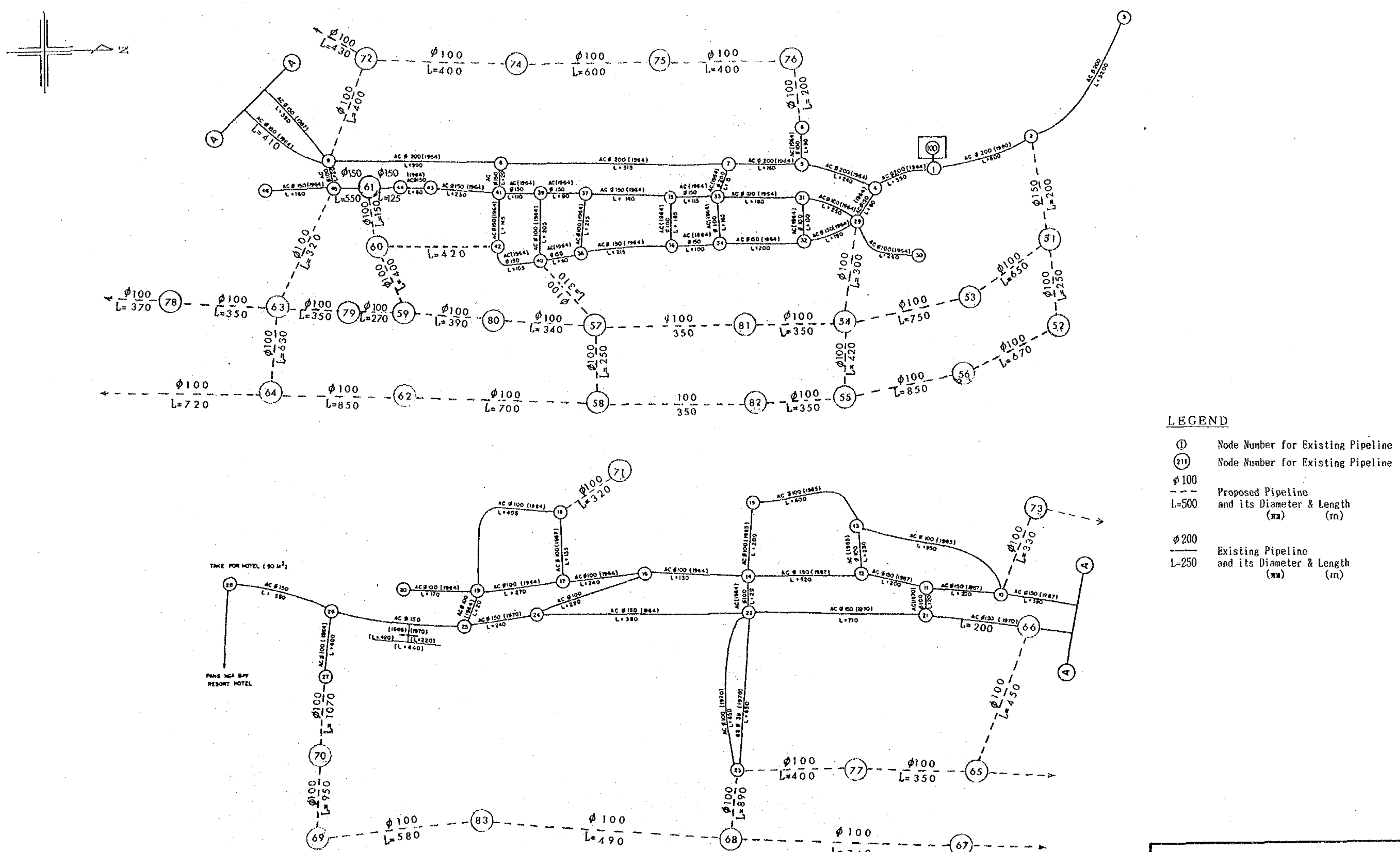


FIGURE 8-2-3

PROPOSED DISTRIBUTION PIPELINE

9. IMPLEMENTATION PLAN

The implementation plan of the total project is proposed as shown in Figure 9-1. In this program, the facility construction consists of the raw water intake, the transmission pipeline, and the distribution pipeline. For the distribution pipelines, the replacement and new construction are recommended to be carried out in two years.

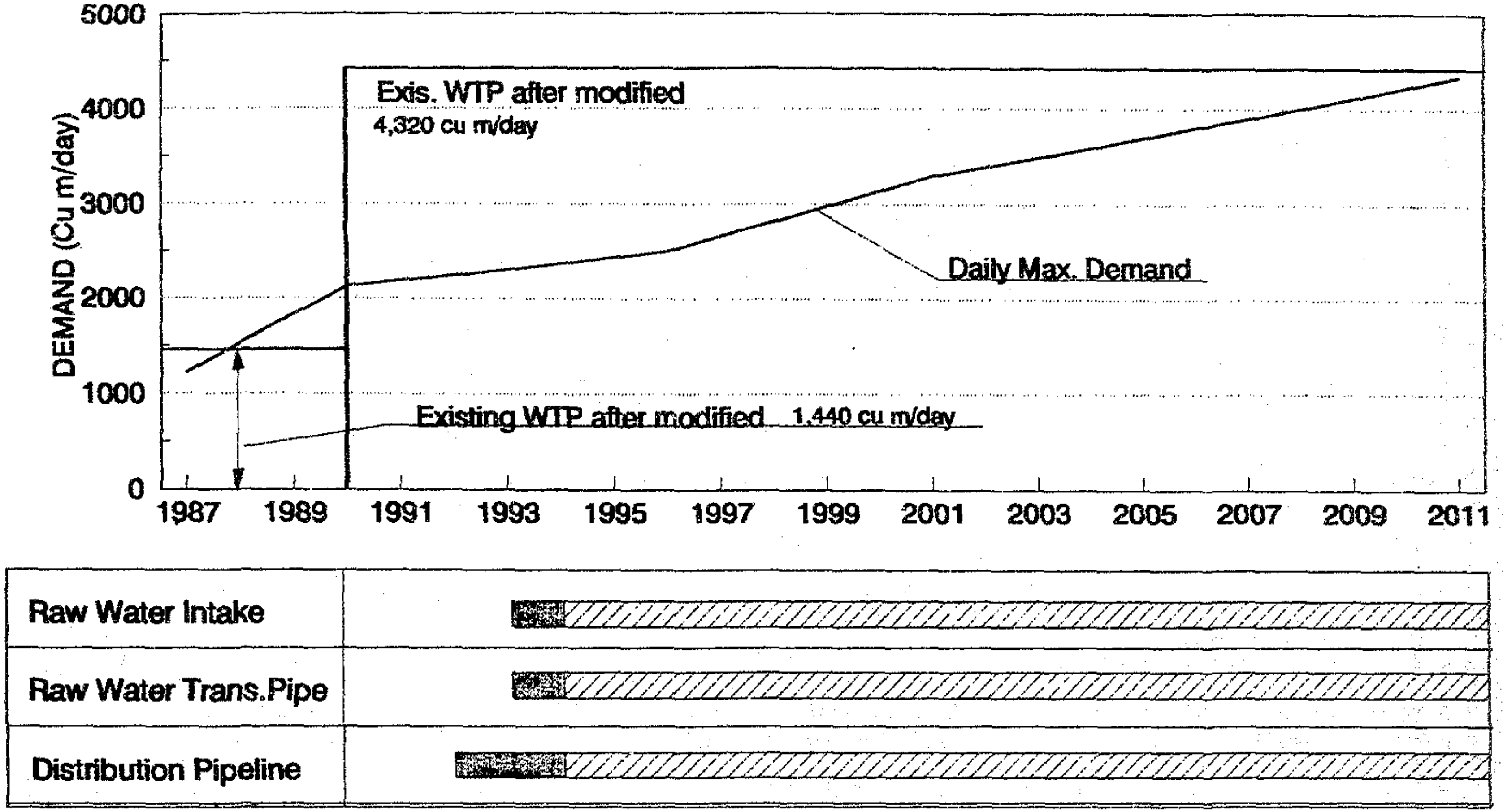


FIGURE 9 - 1
Implementation Plan

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.

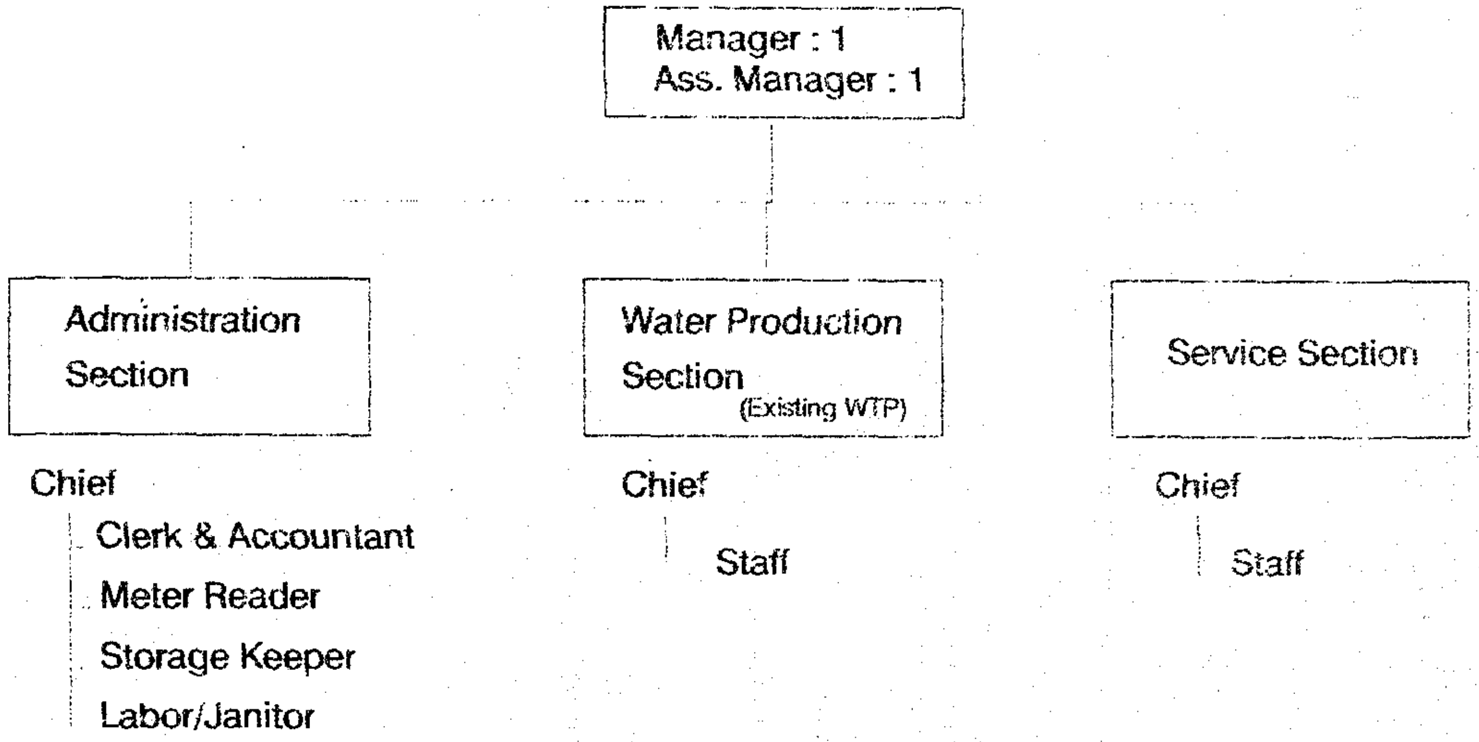


FIGURE 10-1
Proposed Organization

Table 10 - 1 Proposed No. of Staff

Year	No. of Staff Total	Manager	Administrative Chief	Clerk Account	Storage Keeper	Meter Reader	Labor etc.	Water Production Chief	Water Production Staff	Service Section Chief	Service Section Staff
1990	16	1	1	2	1	2	1	1	3	1	3
1991	16	1	1	2	1	2	1	1	3	1	3
1992	16	1	1	2	1	2	1	1	3	1	3
1993	16	1	1	2	1	2	1	1	3	1	3
1994	16	1	1	2	1	2	1	1	3	1	3
1995	16	1	1	2	1	2	1	1	3	1	3
1996	18	1	1	2	1	2	1	1	4	1	4
1997	18	1	1	2	1	2	1	1	4	1	4
1998	20	1	1	3	1	3	1	1	4	1	4
1999	20	1	1	3	1	3	1	1	4	1	4
2000	20	1	1	3	1	3	1	1	4	1	4
2001	23	1	1	3	2	3	1	1	5	1	5
2002	23	1	1	3	2	3	1	1	5	1	5
2003	23	1	1	3	2	3	1	1	5	1	5
2004	23	1	1	3	2	3	1	1	5	1	5
2005	23	1	1	3	2	3	1	1	5	1	5
2006	25	1	1	4	2	4	1	1	5	1	5
2007	25	1	1	4	2	4	1	1	5	1	5
2008	27	1	1	4	2	4	1	1	6	1	6
2009	27	1	1	4	2	4	1	1	6	1	6
2010	27	1	1	4	2	4	1	1	6	1	6
2011	27	1	1	4	2	4	1	1	6	1	6

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	2,761	1,200	1,561
2.Transmission Pipeline	373	112	261
3.Distribution Pipeline	13,809	4,143	9,666
Sub-Total	16,943	5,455	11,488
4.Land Cost	0	0	0
Total	16,943	5,455	11,488

The breakdown of the cost estimates are shown in Tables 11-2 to 6.

Table 11-2 Cost Breakdown of the Raw Water Intake Facility
(unit : Baht 1000)

Item	Total Value	Foreign Currency Portion	Local Currency Portion
A. Civil/Architectural Works	2,000	600	1,400
B.Mechanical Works	450	360	90
C.Electrical Works	225	180	45
D.Miscellaneous	86	60	26
Total	2,761	1,200	1,561

Table 11-3 Cost Breakdown of the Transmission Pipeline

(unit : Baht 1000)

Pipeline From	To	Dia(mm)	L (m)	Total Value	Foreign Currency Portion	Local Currency Portion
Intake	WTP	300	250	373	112	261
Total				373	112	261

Table 11-4 Cost Breakdown of the Distribution Pipeline

(unit :Baht 1000)

Pipe Dia(mm)	L (m)	Material	Total Value	Foreign Currency Portion	Local Currency Portion
(Replacement)					
1st stage					
100	450	AC	198	59	139
150	1,540	AC	939	282	657
200	950	AC	846	254	592
Sub-Total	2,940		1,983	595	1,388
2nd stage					
100	900	AC	396	119	277
150	1,085	AC	662	199	463
200	1,520	AC	792	238	554
Sub-Total	3,505		1,850	556	1,294
3rd stage					
100	1,120	AC	194	58	136
150	1,700	AC	372	112	260
Sub-Total	2,940		566	170	396
(New Construction)					
100	21,110	AC	9,288	2,787	6,502
150	200	AC	122	37	85
Sub-Total	24,065		9,410	2,824	6,587
Total			13,809	4,143	9,666

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	Replacement	Total
1990	197	45	1,509			1,751
1991	334	46	1,585			1,965
1992	337	48	1,664			2,049
1993	340	49	1,747			2,136
1994	460	50	1,834			2,344
1995	469	52	1,926	18		2,465
1996	478	53	2,275	18		2,824
1997	499	56	2,389	18		2,962
1998	521	60	2,787	18		3,386
1999	564	63	2,926	18		3,571
2000	584	67	3,073	18		3,742
2001	631	70	3,710	18		4,429
2002	643	72	3,896	18		4,629
2003	655	74	4,091	18		4,838
2004	668	76	4,295	18		5,057
2005	681	78	4,510	18		5,287
2006	694	81	5,147	18		5,940
2007	707	83	5,404	18		6,212
2008	719	85	6,129	18		6,951
2009	733	87	6,435	18		7,273
2010	746	90	6,757	18		7,611
2011	760	92	7,095	18		7,965

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.

Figure 12-1 Annual Disbursement Schedule
(Unit : Baht 1000)

Year	Intake	Trans. Pipe	Distrib. Pipe	Contin- gency	Sub-Total	Engineering Cost Design	Super- vision	Sub-Total	Direct Operation Cost	Land Cost	Grand Total
Total	2,761	373	13,809	1,694	18,637	1,491	745	2,236	95,382	0	116,256
1990	0	0	0	0	0	0	0	0	1,751	0	1,751
1991	0	0	0	0	0	1,491	0	1,491	1,965	0	3,456
1992	0	0	6,905	690	7,595	0	149	149	2,048	0	9,792
1993	2,761	373	6,905	1,004	11,042	0	596	596	2,136	0	13,775
1994	0	0	0	0	0	0	0	0	2,344	0	2,344
1995	0	0	0	0	0	0	0	0	2,465	0	2,465
1996	0	0	0	0	0	0	0	0	2,824	0	2,824
1997	0	0	0	0	0	0	0	0	2,962	0	2,962
1998	0	0	0	0	0	0	0	0	3,386	0	3,386
1999	0	0	0	0	0	0	0	0	3,571	0	3,571
2000	0	0	0	0	0	0	0	0	3,741	0	3,741
2001	0	0	0	0	0	0	0	0	4,429	0	4,429
2002	0	0	0	0	0	0	0	0	4,629	0	4,629
2003	0	0	0	0	0	0	0	0	4,837	0	4,837
2004	0	0	0	0	0	0	0	0	5,057	0	5,057
2005	0	0	0	0	0	0	0	0	5,287	0	5,287
2006	0	0	0	0	0	0	0	0	5,940	0	5,940
2007	0	0	0	0	0	0	0	0	6,212	0	6,212
2008	0	0	0	0	0	0	0	0	6,950	0	6,950
2009	0	0	0	0	0	0	0	0	7,273	0	7,273
2010	0	0	0	0	0	0	0	0	7,610	0	7,610
2011	0	0	0	0	0	0	0	0	7,964	0	7,964

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. The construction program will be implemented from 1991 to 1993.

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	5,456	11,488	16,944	480	1,011	1,491	240	505	745	6,176	13,004	19,180	545	1,149	1,694	6,721	14,153	20,874
1990	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1991	0	0	0	480	1,011	1,491	0	0	0	480	1,011	1,491	0	0	0	480	1,011	1,491
1992	2,072	4,833	6,905	0	0	0	48	101	149	2,120	4,934	7,054	207	484	691	2,327	5,418	7,745
1993	3,384	6,655	10,039	0	0	0	192	404	596	3,576	7,059	10,635	338	666	1,004	3,914	7,725	11,639
1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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) = 4 % of the total construction cost
3.Engineering Cost (Supervision) = 2 % 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 2,648 thousand Baht (approximately 50 percent of the total project cost) is financed by bilateral loan and 5,178 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 recommeneded 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	19	19	686
1992	0	100	100	3,715
1993	0	238	238	8,824
1994	0	238	238	8,824
1995	0	238	238	8,824
1996	0	238	238	8,824
1997	0	238	238	8,824
1998	0	238	238	8,824
1999	0	238	238	8,824
2000	0	238	238	8,824
2001	339	238	577	8,824
2002	348	229	577	8,485
2003	357	220	577	8,138
2004	367	210	577	7,781
2005	377	200	577	7,414
2006	387	190	577	7,037
2007	397	180	577	6,651
2008	408	169	577	6,253
2009	419	158	577	5,845
2010	430	147	577	5,427
2011	442	135	577	4,996
2012	454	123	577	4,554
2013	466	111	577	4,101
2014	479	98	577	3,635
2015	492	85	577	3,156
2016	505	72	577	2,664
2017	518	58	577	2,159
2018	532	44	577	1,641
2019	547	30	577	1,108
2020	562	15	577	562
Total	8,824	4,736	13,560	

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	44	44	403
1992	0	266	266	2,415
1993	0	570	570	5,178
1994	310	570	879	5,178
1995	344	536	879	4,868
1996	382	498	879	4,525
1997	423	456	879	4,143
1998	470	409	879	3,720
1999	522	357	879	3,250
2000	579	300	879	2,728
2001	643	236	879	2,149
2002	714	166	879	1,506
2003	792	87	879	792
2004	0	0	0	0
2005	0	0	0	0
2006	0	0	0	0
2007	0	0	0	0
2008	0	0	0	0
2009	0	0	0	0
2010	0	0	0	0
2011	0	0	0	0
2012	0	0	0	0
2013	0	0	0	0
Total	5,178	4,494	9,672	

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	63	63	1,089
1992	0	366	366	6,130
1993	0	808	808	14,002
1994	310	808	1,117	14,002
1995	344	774	1,117	13,692
1996	382	736	1,117	13,349
1997	423	694	1,117	12,967
1998	470	647	1,117	12,544
1999	522	596	1,117	12,074
2000	579	538	1,117	11,552
2001	981	475	1,456	10,973
2002	1,061	395	1,456	9,991
2003	1,149	307	1,456	8,930
2004	367	210	577	7,781
2005	377	200	577	7,414
2006	387	190	577	7,037
2007	397	180	577	6,651
2008	408	169	577	6,253
2009	419	158	577	5,845
2010	430	147	577	5,427
2011	442	135	577	4,996
2012	454	123	577	4,554
2013	466	111	577	4,101
2014	479	98	577	3,635
2015	492	85	577	3,156
2016	505	72	577	2,664
2017	518	58	577	2,159
2018	532	44	577	1,641
2019	547	30	577	1,108
2020	562	15	577	562
Total	14,002	9,230	23,232	

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	480	1,011	1,491
1992	2,120	4,934	7,054
1993	3,576	7,059	10,635
1994	0	0	0
1995	0	0	0
1996	0	0	0
1997	0	0	0
1998	0	0	0
1999	0	0	0
2000	0	0	0
2001	0	0	0
Total	6,176	13,004	19,180

b. Funding allocation

(Unit : Baht x 1,000)

Year	Bilateral Loan	Local Loan	PWA's Equity	Total
1990	0	0	0	0
1991	686	402.5	402.5	1,491
1992	3,029	2,012.5	2,012.5	7,054
1993	5,109	2,763.0	2,763.0	10,635
1994	0	0	0	0
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
2001	0	0	0	0
Total	8,824	5,178.0	5,178.0	19,180

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	18	13	0	1	0	0	0	0	0	79
1992	100	1	0	0	0	0	0	0	0	208
1993	100	1	0	0	0	0	0	0	0	208
1994	100	1	0	0	0	0	0	0	0	208
1995	100	1	0	0	0	0	0	0	0	208
1996	102	1	0	0	0	0	0	0	0	217
1997	121	1	0	1	0	0	0	0	0	257
1998	121	1	0	1	0	0	0	0	0	257
1999	121	1	0	1	0	0	0	0	0	257
2000	121	1	2	1	0	0	0	0	0	265
2001	121	2	2	3	0	1	0	0	0	294
2002	179	2	0	0	0	0	0	0	0	372
2003	179	2	2	0	0	0	0	0	0	380
2004	179	2	1	0	0	0	0	0	0	376
2005	179	2	1	0	0	0	0	0	0	376
2006	180	2	0	0	0	0	0	0	0	375
2007	187	1	0	0	0	0	0	0	0	386
2008	187	1	0	0	0	0	0	0	0	386
2009	187	1	0	0	0	0	0	0	0	386
2010	187	1	0	0	0	0	0	0	0	386
2011	187	2	2	0	0	0	0	0	0	386

Note : 0.5 inch ; Domestic
0.75 inch ; Commercial
1 inch ; Industrial, Government & School
1.5 inch ; Tourism
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	1,026	46	29	8	0	1	0	0	149
1991	1,044	59	29	9	0	1	0	0	154
1992	1,144	60	29	9	0	1	0	0	166
1993	1,244	61	29	9	0	1	0	0	179
1994	1,344	62	29	9	0	1	0	0	191
1995	1,444	63	29	9	0	1	0	0	203
1996	1,546	66	29	9	0	1	0	0	216
1997	1,667	67	29	10	0	1	0	0	231
1998	1,788	68	29	11	0	1	0	0	247
1999	1,909	69	29	12	0	1	0	0	262
2000	2,030	70	31	13	0	1	0	0	278
2001	2,151	72	33	16	0	2	0	0	297
2002	2,330	74	33	16	0	2	0	0	319
2003	2,509	76	35	16	0	2	0	0	342
2004	2,688	78	36	16	0	2	0	0	364
2005	2,867	80	37	16	0	2	0	0	386
2006	3,047	82	37	16	0	2	0	0	408
2007	3,234	83	37	16	0	2	0	0	431
2008	3,421	84	37	16	0	2	0	0	453
2009	3,608	85	37	16	0	2	0	0	476
2010	3,795	86	37	16	0	2	0	0	499
2011	3,982	88	39	16	0	2	0	0	522

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

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)	412	442	473	506	541	577	614	654	695	737	782	828
(cu.m/month)	12,360	13,260	14,190	15,180	16,230	17,310	18,420	19,620	20,850	22,110	23,460	24,840
No.of Connections	1,026	1,044	1,144	1,244	1,344	1,444	1,546	1,667	1,788	1,909	2,030	2,151
Water Cons./Conn.	12.05	12.70	12.40	12.20	12.08	11.99	11.91	11.77	11.66	11.58	11.56	11.55
Water Sales(*1,000Baht)	48	52	55	59	63	67	71	76	78	85	90	96

(2)Governmental/Institutional

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water Sales (cu.m/d)	383	386	390	392	395	398	400	404	407	410	413	416
(cu.m/month)	11,490	11,580	11,700	11,760	11,850	11,940	12,000	12,120	12,210	12,300	12,390	12,480
No.of Connections	29	29	29	29	29	29	31	31	31	31	31	33
Water Cons./Conn.												
Water Sales(*1,000Baht)	103	105	105	106	107	108	108	109	110	110	111	110

(3)Commercial

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water Sales (cu.m/d)	105	107	110	112	114	116	118	121	123	125	128	130
(cu.m/month)	3,150	3,210	3,300	3,360	3,420	3,480	3,540	3,630	3,690	3,750	3,840	3,900
No.of Connections	46	59	60	61	62	63	66	67	68	69	70	72
Water Cons./Conn.	68.48	54.41	55.00	55.08	55.16	55.24	53.64	54.18	54.26	54.35	54.86	54.17
Water Sales(*1,000Baht)	20	19	20	20	20	21	21	21	22	22	23	23

(4)Industrial

Item/Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water Sales (cu.m/d)	15	16	17	17	18	19	19	20	21	22	23	24
(cu.m/month)	450	480	510	510	540	570	570	600	630	660	690	720
No.of Connections	1	1	1	1	1	1	1	1	1	1	1	2
Water Cons./Conn.	450.00	480.00	510.00	510.00	540.00	570.00	570.00	600.00	630.00	660.00	690.00	360.00
Water Sales(*1,000Baht)	4	4	4	4	5	5	5	5	6	6	6	6

(5)Tourism

Item/Year	1990	1991	1982	1993	1994	1995	1996	1997	1998	1999	2000	2001
Water Sales (cu.m/d)	294	294	294	294	294	294	294	347	400	453	505	558
(cu.m/month)	8,820	8,820	8,820	8,820	8,820	8,820	8,820	10,410	12,000	13,590	15,150	16,740
No.of Connections	8	9	9	9	9	9	9	10	11	12	13	16
Water Cons./Conn.	1,102.50	980.00	980.00	980.00	980.00	980.00	980.00	1,041.00	1,090.91	1,132.50	1,165.38	1,046.25
Water Sales(*1,000Baht)	80	79	79	79	79	79	79	94	108	123	137	151

Total	255	259	263	268	274	280	284	305	324	346	367	386

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)	884	944	1,006	1,071	1,138	1,199	1,261	1,326	1,393	1,462
(cu.m/month)	26,520	28,320	30,180	32,130	34,140	35,970	37,830	39,780	41,790	43,860
No.of Connections	2,330	2,509	2,688	2,867	3,047	3,234	3,421	3,608	3,795	3,982
Water Cons./Conn.	11.38	11.29	11.23	11.21	11.20	11.12	11.06	11.03	11.01	11.01
Water Sales(*1,000Baht)	102	109	116	123	131	138	145	152	160	167

(2)Governmental/Institu

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water Sales (cu.m/d)	420	425	429	434	438	441	445	447	450	453
(cu.m/month)	12,600	12,750	12,870	13,020	13,140	13,230	13,350	13,410	13,500	13,590
No.of Connections	34	35	36	37	37	37	37	37	37	39
Water Cons./Conn.										
Water Sales(*1,000Baht)	111	112	112	114	115	116	117	117	119	119

(3)Commercial

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water Sales (cu.m/d)	133	137	140	144	147	149	152	154	156	158
(cu.m/month)	3,990	4,110	4,200	4,320	4,410	4,470	4,560	4,620	4,680	4,740
No.of Connections	74	76	78	80	82	83	84	85	86	88
Water Cons./Conn.	53.92	54.08	53.85	54.00	53.78	53.86	54.29	54.35	54.42	53.86
Water Sales(*1,000Baht)	23	24	25	25	26	26	27	27	28	28

(4)Industrial

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water Sales (cu.m/d)	25	26	27	29	30	31	32	34	35	36
(cu.m/month)	750	780	810	870	900	930	960	1,020	1,050	1,080
No.of Connections	2	2	2	2	2	2	2	2	2	3
Water Cons./Conn.	375.00	390.00	405.00	435.00	450.00	465.00	480.00	510.00	525.00	360.00
Water Sales(*1,000Baht)	6	7	7	8	8	8	8	9	9	9

(5)Tourism

Item/Year	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Water Sales (cu.m/d)	558	558	558	558	558	558	558	558	558	558
(cu.m/month)	16,740	16,740	16,740	16,740	16,740	16,740	16,740	16,740	16,740	16,740
No.of Connections	16	16	16	16	16	16	16	16	16	16
Water Cons./Conn.	1,046.25	1,046.25	1,046.25	1,046.25	1,046.25	1,046.25	1,046.25	1,046.25	1,046.25	1,046.25
Water Sales(*1,000Baht)	151	151	151	151	151	151	151	151	151	151

Total	393	403	411	421	431	439	448	456	467	474

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	310	344	382	423	470	522	579	643	714	792		
Laon	0	1,089	5,042	7,872												
Local loan	0	403	2,013	2,763												
Foreign loan	0	686	3,029	5,109												
Operating Revenue	2,903	3,403	3,593	3,667	3,753	3,838	3,909	4,221	4,470	4,754	5,035	5,316	5,501	5,655	5,771	5,915
Water Sales	2,700	3,108	3,156	3,216	3,288	3,360	3,408	3,660	3,888	4,152	4,404	4,632	4,716	4,836	4,932	5,052
Connection Fee	0	79	208	208	208	208	217	257	257	257	265	294	372	380	376	376
Service Charge	149	154	166	179	191	203	216	231	247	262	278	297	319	342	364	386
Ohter Income	54	62	63	64	66	67	68	73	78	83	88	93	94	97	99	101
Total Inflow	2,903	4,492	8,635	11,539	4,063	4,182	4,291	4,644	4,940	5,276	5,614	5,959	6,215	6,447	5,771	5,915
Cash Outflow																
Project expenditures																
Local portion	0	1,011	4,934	7,059												
Foreign portion	0	480	2,120	3,576												
Amortization																
Principal	0	0	0	0	310	344	382	423	470	522	579	981	1,061	1,149	367	377
Interest	0	63	366	808	808	774	736	694	647	596	538	475	395	307	210	200
Operating Expenses	4,001	4,216	4,378	4,482	4,594	4,721	5,102	5,308	5,773	6,067	6,347	7,067	7,336	7,586	7,836	8,103
O & M Cost	2,615	2,701	2,788	2,879	2,975	3,087	3,452	3,583	3,998	4,235	4,456	5,112	5,323	5,543	5,774	6,015
Connection Expenses	0	40	104	104	104	104	109	129	129	129	133	147	186	190	188	188
Share of Head Office	1,386	1,475	1,486	1,499	1,515	1,530	1,541	1,596	1,646	1,703	1,758	1,808	1,827	1,853	1,874	1,900
Total Outflow	4,001	5,770	11,798	15,925	5,712	5,839	6,220	6,425	6,890	7,185	7,464	8,523	8,792	9,042	8,413	8,680
Net Cash flow	-1,098	-1,278	-3,163	-4,386	-1,649	-1,657	-1,928	-1,780	-1,950	-1,908	-1,849	-2,564	-2,577	-2,595	-2,642	-2,765
Accumulated	-1,098	-2,376	-5,539	-9,925	-11,574	-13,231	-15,159	-16,940	-18,889	-20,798	-22,647	-25,212	-27,788	-30,384	-33,026	-35,791

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	6,058	6,190	6,323	6,443	6,601	6,710	6,710	6,710	6,710	6,710	6,710	6,710	6,710	6,710	6,710
Water Sales	5,172	5,268	5,376	5,472	5,604	5,688	5,688	5,688	5,688	5,688	5,688	5,688	5,688	5,688	5,688
Connection Fee	375	386	386	386	386	386	386	386	386	386	386	386	386	386	386
Service Charge	408	431	453	476	499	522	522	522	522	522	522	522	522	522	522
Ohter Income	103	105	108	109	112	114	114	114	114	114	114	114	114	114	114
Total Inflow	6,058	6,190	6,323	6,443	6,601	6,710	6,710	6,710	6,710	6,710	6,710	6,710	6,710	6,710	6,710
Cash Outflow															
Project expenditures															
Local portion															
Foreign portion															
Amortization															
Principal	387	397	408	419	430	442	454	466	479	492	505	518	532	547	562
Interest	190	180	169	158	147	135	123	111	98	85	72	58	44	30	15
Operating Expenses	8,793	9,105	9,883	10,240	10,698	11,086	11,086	11,086	11,086	11,086	11,086	11,086	11,086	11,086	11,086
O & M Cost	6,679	6,965	7,719	8,055	8,484	8,854	8,854	8,854	8,854	8,854	8,854	8,854	8,854	8,854	8,854
Connection Expenses	188	193	193	193	193	193	193	193	193	193	193	193	193	193	193
Share of Head Office	1,926	1,947	1,971	1,992	2,021	2,039	2,039	2,039	2,039	2,039	2,039	2,039	2,039	2,039	2,039
Total Outflow	9,370	9,682	10,460	10,817	11,275	11,663	11,663	11,663	11,663	11,663	11,663	11,662	11,662	11,663	11,663
Net Cash flow	-3,311	-3,492	-4,137	-4,374	-4,674	-4,953	-4,953	-4,953	-4,953	-4,953	-4,953	-4,952	-4,952	-4,955	-4,953
Accumulated	-39,102	-42,594	-46,731	-51,105	-55,779	-60,732	-65,685	-70,638	-75,591	-80,545	-85,498	-90,450	-95,402	-100,356	-105,309

As clearly shown in this table, net annual revenue surpluses are forecasted not 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 not continuously raise profit surpluses and the cumulative deficits will be 60,732 thousand Baht in 2011.

These deficits shall be covered with PWA's own fund or water tariff rate shall be increased to achieve a financial self-standing of waterworks management.

2) Share of Head and Regional Office Overhead Expenses

PWA is administratively, technically, economically and financially independent from the central government. Therefore, 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 the 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 after debt service which will register 11.38 Baht per cu m in 2011 or equal to the average unit water cost from year 1990 to 2011 and almost maximum level of present water tariff structure of PWA. And average unit water cost from 1990 to 2020 is projected to stand at 11.37 Baht or maximum level of present water tariff.

4) Average Water Rate

In view of revenue aspects, average water tariff is calculated based on 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	1,210	0	4,001	4,001	9.06
1991	1,245	1,491	4,216	5,707	12.56
1992	1,282	7,054	4,378	11,432	24.43
1993	1,321	10,635	4,482	15,117	31.35
1994	1,361	0	4,594	4,594	9.25
1995	1,403	0	4,721	4,721	9.22
1996	1,446	0	5,102	5,102	9.67
1997	1,544	0	5,308	5,308	9.42
1998	1,645	0	5,773	5,773	9.61
1999	1,747	0	6,067	6,067	9.51
2000	1,850	0	6,347	6,347	9.40
2001	1,956	0	7,067	7,067	9.90
2002	2,022	0	7,336	7,336	9.94
2003	2,090	0	7,586	7,586	9.94
2004	2,162	0	7,836	7,836	9.93
2005	2,236	0	8,103	8,103	9.93
2006	2,313	0	8,793	8,793	10.42
2007	2,379	0	9,105	9,105	10.49
2008	2,448	0	9,883	9,883	11.06
2009	2,519	0	10,240	10,240	11.14
2010	2,593	0	10,698	10,698	11.30
2011	2,668	0	11,086	11,086	11.38
2012	2,668	0	11,086	11,086	11.38
2013	2,668	0	11,086	11,086	11.38
2014	2,668	0	11,086	11,086	11.38
2015	2,668	0	11,086	11,086	11.38
2016	2,668	0	11,086	11,086	11.38
2017	2,668	0	11,086	11,086	11.38
2018	2,668	0	11,086	11,086	11.38
2019	2,668	0	11,086	11,086	11.38
2020	2,668	0	11,086	11,086	11.38
	Average Unit Water Cost (1990-2020) :				11.37

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	1,210	2,700	6.11
1991	1,245	3,108	6.84
1992	1,282	3,156	6.74
1993	1,321	3,216	6.67
1994	1,361	3,288	6.62
1995	1,403	3,360	6.56
1996	1,446	3,408	6.46
1997	1,544	3,660	6.49
1998	1,645	3,888	6.48
1999	1,747	4,152	6.51
2000	1,850	4,404	6.52
2001	1,956	4,632	6.49
2002	2,022	4,716	6.39
2003	2,090	4,836	6.34
2004	2,162	4,932	6.25
2005	2,236	5,052	6.19
2006	2,313	5,172	6.13
2007	2,379	5,268	6.07
2008	2,448	5,376	6.02
2009	2,519	5,472	5.95
2010	2,593	5,604	5.92
2011	2,668	5,688	5.84
2012	2,668	5,688	5.84
2013	2,668	5,688	5.84
2014	2,668	5,688	5.84
2015	2,668	5,688	5.84
2016	2,668	5,688	5.84
2017	2,668	5,688	5.84
2018	2,668	5,688	5.84
2019	2,668	5,688	5.84
2020	2,668	5,688	5.84

APPENDICES

APPENDIX A-1-1

Meteorological Data

1 Meteorological Data

Table A1-1-1 : Monthly Rainfall at Phang Nga

Code; RM 3701
Station; Amphur Muang Phang Nga

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1956	46.2	76.4	142.4	241.2	406.8	353.0	227.6	558.4	473.6	335.5	107.4	27.4	2995.9
1957	35.4	16.4	147.0	182.9	182.9	294.7	538.3	385.9	511.3	232.3	246.9	42.0	2816.0
1958	32.5	47.6	8.7	87.3	227.6	504.5	296.2	469.6	260.2	219.6	42.0	0.0	2195.8
1959	0.4	49.0	-	-	-	-	-	-	234.1	209.5	112.4	49.9	-
1960	101.9	58.5	26.0	56.7	307.5	420.2	420.2	459.2	474.9	207.4	224.8	14.3	2771.6
1961	61.1	66.0	89.7	135.1	301.1	265.7	131.9	211.2	219.8	292.1	151.1	100.7	2025.5
1962	45.5	0.0	61.8	107.6	184.9	235.1	399.9	231.5	338.9	181.4	63.6	72.1	1922.3
1963	5.5	18.4	47.0	43.8	253.4	314.4	88.8	471.7	409.7	373.6	122.4	83.6	2232.3
1964	31.9	102.1	0.0	224.4	497.9	84.0	190.0	173.4	487.6	134.5	375.7	105.2	2406.7
1965	64.8	127.1	-	-	-	-	-	-	-	-	-	-	-
1966	71.4	12.4	105.9	348.1	535.8	344.3	386.0	636.9	166.3	336.0	192.4	60.7	3196.2
1967	-	-	55.3	223.8	322.9	526.7	505.9	518.1	390.2	503.9	958.0	-	-
1968	-	-	-	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	-	-	-	-	-	-
1970	-	-	-	-	-	-	-	-	-	-	-	-	-
1971	0.0	123.8	192.4	77.0	440.7	470.9	228.9	228.6	310.1	558.8	90.6	46.5	2768.3
1972	43.2	59.3	110.8	313.7	168.9	90.2	301.7	224.0	305.8	161.4	115.1	21.2	1915.3
1973	31.5	0.0	197.7	94.5	76.8	370.4	429.8	340.5	196.2	232.1	62.0	0.0	2031.5
1974	0.0	48.7	196.3	159.6	428.8	233.0	61.3	351.6	307.7	393.4	185.6	-	-
1975	148.2	20.5	150.5	238.3	139.1	715.3	226.2	294.0	464.5	338.2	198.7	2.4	2935.9
1976	0.0	43.2	56.3	237.5	325.2	232.6	498.6	264.5	551.9	167.8	153.8	1.4	2532.8
1977	0.0	0.7	0.0	0.0	48.9	121.6	215.4	398.0	377.8	253.4	132.4	17.8	1566.0
1978	77.3	14.8	111.8	108.7	246.1	261.9	344.5	297.9	183.8	107.3	31.4	8.4	1793.9
1979	0.0	0.2	9.6	42.6	85.3	158.2	301.7	128.3	288.7	56.0	135.2	0.0	1205.8
1980	0.0	0.0	0.0	2.8	109.6	236.4	415.4	159.8	148.5	0.0	17.5	0.0	1090.0
1981	0.0	0.0	0.0	68.2	212.5	252.5	242.2	198.0	-	182.3	90.1	0.0	-
1982	0.0	0.0	50.3	162.7	361.0	160.7	807.3	431.1	285.3	150.4	197.0	32.7	2638.5
1983	0.0	0.0	88.5	0.0	481.1	242.7	346.8	411.1	392.8	153.3	62.2	21.1	2199.6
1984	0.0	0.0	31.1	270.2	310.3	847.9	194.0	307.2	244.2	124.1	19.3	109.0	2457.3
1985	28.7	4.7	113.9	197.7	53.5	479.0	100.1	238.0	369.8	261.4	49.8	5.3	1901.9
1986	0.0	20.7	52.2	251.9	482.6	365.8	283.1	681.5	328.4	218.6	179.4	0.0	2864.2
1987	10.1	0.0	26.5	40.3	66.4	80.9	60.7	271.4	65.0	227.4	111.9	51.4	1012.0

Source : Meteorological Department

Table A1-1-2 : Monthly Rainfall at Takua Thung

Code; RM 3702
Station; Amphur Takua Thung, Phang Nga

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1955	0.0	14.4	119.0	291.1	324.7	418.6	136.7	249.1	248.6	404.0	308.3	13.3	2527.8
1956	5.9	29.1	245.2	142.4	407.0	353.7	236.6	439.3	389.8	171.5	151.6	21.8	2593.9
1957	34.8	17.7	77.4	173.5	366.2	357.1	615.7	462.0	617.4	278.7	262.4	87.7	3350.6
1958	18.6	17.8	13.8	108.5	344.3	500.6	215.7	341.8	492.3	504.8	117.2	18.1	2693.5
1959	4.2	15.2	290.0	239.8	260.4	282.8	771.4	520.4	360.8	360.8	325.0	163.1	3593.9
1960	99.4	102.8	6.7	56.9	585.8	466.8	465.6	589.2	656.3	360.4	309.3	132.9	3832.1
1961	89.3	70.7	42.6	149.6	428.3	447.1	203.3	288.1	520.4	390.6	231.3	95.1	2956.4
1962	43.2	15.8	158.6	264.2	287.2	398.7	483.3	320.5	499.6	575.5	85.8	51.4	3183.8
1963	13.6	38.6	23.1	8.5	377.7	420.6	195.7	479.3	680.2	449.9	283.3	63.7	3034.2
1964	127.1	55.5	13.8	287.9	931.9	192.7	130.4	584.5	711.8	195.7	198.6	78.1	3508.0
1965	3.3	75.9	112.3	174.4	438.7	470.9	597.6	475.2	759.1	261.4	248.7	114.3	3731.8
1966	61.4	105.3	57.1	267.8	632.3	327.6	505.6	507.4	219.0	412.8	194.3	116.3	3406.9
1967	49.3	15.2	59.6	152.8	214.0	550.8	414.3	539.1	373.6	477.9	115.4	3.5	2965.5
1968	30.2	0.0	9.1	244.6	436.1	566.6	452.9	913.2	507.7	203.9	149.6	96.8	3610.7
1969	199.2	34.2	113.2	45.0	280.5	703.9	435.3	257.2	842.2	434.4	269.2	58.3	3672.6
1970	90.9	31.2	156.9	278.6	68.7	477.9	498.4	460.6	502.1	257.1	183.6	88.4	3094.4
1971	0.0	213.0	263.6	171.5	454.8	623.1	248.4	331.0	315.6	648.7	102.0	38.5	3410.2
1972	47.1	44.4	145.8	149.7	218.7	255.4	393.8	237.5	425.3	189.8	146.4	75.7	2329.6
1973	24.2	19.2	232.5	192.2	214.4	636.1	646.8	640.7	421.9	438.3	211.0	61.3	3738.6
1974	31.2	30.3	168.5	209.5	445.2	293.2	369.8	496.9	447.6	523.5	217.3	0.0	3233.0
1975	143.9	74.4	114.2	253.2	200.1	690.9	225.3	370.8	531.5	392.9	164.4	133.9	3295.5
1976	28.0	20.8	162.2	164.4	546.8	304.8	436.2	236.0	566.4	175.1	127.9	56.6	2825.2
1977	16.0	98.5	0.0	121.7	377.4	254.3	230.5	455.0	439.8	393.8	97.9	36.3	2521.2
1978	86.6	28.5	90.2	88.7	348.8	542.4	579.7	480.6	494.4	348.8	93.9	22.3	3204.9
1979	16.5	35.9	34.8	164.3	376.4	431.3	637.3	369.0	1399.2	216.1	154.5	16.0	3851.3
1980	11.0	108.0	48.0	113.7	321.2	471.4	593.2	644.9	467.0	261.1	363.5	47.5	3450.5
1981	3.0	66.4	36.1	301.9	352.7	492.8	268.1	245.7	312.2	293.8	225.4	-	-
1982	0.0	62.1	47.1	273.9	499.7	232.5	794.1	534.2	421.4	210.8	184.9	28.3	3289.0
1983	20.3	0.0	63.4	13.2	367.0	369.8	515.8	562.9	619.8	385.7	-	-	-
1984	43.2	0.0	13.3	191.7	208.6	594.7	293.1	450.8	377.0	349.4	68.7	120.9	2711.4
1985	101.9	26.1	179.0	118.4	387.9	291.6	78.1	555.6	190.8	408.2	106.4	112.1	2556.1
1986	0.0	0.0	0.0	345.3	449.6	124.8	229.3	473.8	683.5	262.4	247.8	0.0	2816.5
1987	59.0	0.0	2.2	88.1	181.5	355.3	220.5	514.8	202.8	303.9	282.4	90.2	2300.7

Source : Meteorological Department

Table A1-1-3 : Monthly Rainfall at Thai Muang

Code; RM 3703
Station; Amphur Thai Muang, Phang Nga

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1952	11.0	94.5	216.5	126.9	175.8	348.9	218.8	521.5	151.8	447.0	191.1	21.9	2525.7
1953	221.1	157.8	32.3	457.6	850.5	344.4	577.5	183.2	718.4	1034.5	378.0	0.0	4955.3
1954	123.2	70.7	219.3	199.5	312.6	1134.2	729.9	1004.6	821.6	431.8	157.6	38.5	5243.5
1955	0.0	0.0	0.0	26.7	251.8	637.8	56.9	312.5	35.2	18.5	0.0	0.0	1339.4
1956	0.0	0.0	0.0	39.6	55.5	100.7	75.2	78.2	60.3	61.8	0.0	35.8	507.1
1957	22.3	3.7	56.8	180.0	309.6	348.8	728.5	424.9	521.7	262.9	72.7	64.9	2996.8
1958	38.3	14.1	51.9	158.9	367.6	191.2	266.0	266.0	272.7	379.5	132.2	11.1	2149.5
1959	6.6	0.0	307.2	254.0	338.8	376.7	595.9	428.7	567.9	436.3	140.6	142.6	3595.3
1960	26.9	81.9	4.4	81.9	848.7	399.9	494.6	695.1	644.9	182.5	449.4	56.5	3966.7
1961	51.4	24.1	89.0	93.8	468.0	234.5	140.1	187.8	405.6	299.7	252.4	121.4	2367.8
1962	84.7	0.0	101.9	124.7	316.2	502.3	351.6	405.9	371.8	491.8	105.7	35.5	2892.1
1963	58.9	16.3	0.0	0.0	295.5	336.2	297.0	510.7	391.5	601.8	215.0	65.7	2788.6
1964	92.3	112.6	9.1	147.8	702.1	196.5	280.9	456.5	667.1	326.6	321.8	62.3	3375.6
1965	-	-	-	-	-	-	-	-	-	-	-	-	-
1966	75.6	58.2	46.3	185.6	497.5	411.7	409.6	349.9	161.8	723.3	75.1	99.4	3094.0
1967	36.9	13.6	49.2	81.3	299.5	347.9	255.8	365.8	329.0	645.3	133.7	13.6	2571.6
1968	32.3	1.1	13.8	295.6	415.2	542.2	499.6	542.9	481.6	181.1	69.2	68.6	3143.2
1969	117.8	39.7	71.0	75.9	310.1	746.9	259.4	203.4	637.4	269.1	229.2	58.5	3018.4
1970	73.7	10.0	136.3	184.9	301.6	435.4	609.2	329.3	489.9	452.9	278.1	72.7	3374.0
1971	0.0	160.6	213.8	110.6	696.2	533.5	295.1	562.7	412.2	554.2	49.2	85.3	3673.4
1972	20.6	26.0	45.9	259.7	298.9	263.5	283.3	185.1	505.3	212.3	202.9	146.0	2449.5
1973	19.8	17.0	119.4	151.8	335.7	631.0	790.4	303.4	800.8	660.5	134.1	35.1	3999.0
1974	32.3	69.2	165.5	302.6	214.5	291.9	355.9	286.4	527.5	690.6	334.2	98.6	3369.2
1975	159.1	60.4	71.1	144.3	385.4	746.3	364.5	233.0	486.8	62.0	0.0	0.0	2712.9
1976	20.4	8.7	93.0	208.3	424.6	228.0	352.9	252.7	371.6	258.1	175.0	34.6	2427.9
1977	14.3	67.9	0.0	1.5	440.6	334.6	415.9	383.9	650.7	346.4	151.6	58.9	2866.3
1978	82.7	105.3	29.4	170.6	277.8	631.0	501.1	292.1	531.8	308.5	96.1	21.0	3047.4
1979	22.1	22.4	7.6	194.6	194.9	262.1	640.7	163.9	547.2	208.0	152.9	0.0	2416.4
1980	21.2	25.4	55.0	125.7	329.1	522.9	574.8	633.2	319.0	375.1	211.1	92.5	3285.0
1981	11.1	4.8	2.6	154.0	445.4	437.9	193.2	149.4	26.8	128.5	344.3	7.7	1905.7
1982	1.2	6.0	16.0	429.9	380.7	177.7	546.0	349.6	278.2	300.2	205.7	29.5	2720.7
1983	45.1	0.0	22.6	81.5	297.9	451.2	438.7	592.7	714.2	273.7	292.6	6.2	3216.4
1984	97.8	36.6	101.8	329.9	490.3	527.3	355.8	130.6	427.1	255.5	69.9	101.3	2923.9
1985	44.6	36.7	79.1	252.0	537.7	269.6	140.2	324.1	527.3	527.7	210.4	125.1	3074.5
1986	9.2	0.0	29.9	265.3	239.2	282.4	441.0	353.6	829.5	249.2	434.1	0.0	3133.4
1987	28.7	0.0	7.2	52.3	140.1	232.5	105.7	395.9	259.2	493.5	348.8	36.1	2100.0

Source : Meteorological Department

Table A1-1-4 : Monthly Rainfall at Kapong

Code; RM 3706
Station; Amphur Kapong, Phang Nga

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1966	-	-	-	-	-	-	124.5	921.5	351.6	475.9	116.9	168.6	2159.0
1967	45.0	0.0	22.0	241.4	437.9	767.4	689.7	766.1	440.0	724.3	103.4	5.7	4242.9
1968	3.5	0.0	0.0	489.4	570.7	822.1	638.4	1005.9	662.1	223.9	64.0	107.5	4587.5
1969	137.9	63.7	201.7	119.9	186.2	902.8	360.3	341.9	1248.9	440.3	227.3	0.0	4230.9
1970	81.7	7.9	190.9	329.3	329.2	668.5	698.1	507.2	685.6	431.2	279.2	121.5	4330.3
1971	13.5	343.3	194.2	136.7	485.6	693.3	235.2	418.4	478.2	511.0	60.0	28.1	3597.5
1972	16.0	75.3	74.6	384.3	205.6	461.6	418.3	425.7	616.9	265.7	152.7	78.1	3174.8
1973	54.3	12.7	153.7	277.4	229.2	754.5	833.8	692.0	570.5	531.6	221.0	114.3	4445.0
1974	0.0	79.7	107.5	271.5	417.6	567.8	363.1	770.6	531.6	884.3	419.1	0.0	4412.8
1975	181.3	30.0	167.3	298.8	428.1	895.6	273.5	479.9	548.5	513.3	262.5	54.6	4133.4
1976	7.0	6.8	192.5	188.3	834.6	339.9	686.2	435.9	789.7	319.6	168.6	36.9	4006.0
1977	90.6	64.7	0.0	109.3	582.8	363.6	301.8	891.3	682.8	514.3	71.6	10.6	3683.4
1978	40.8	60.7	154.8	341.8	558.1	846.9	899.6	871.0	705.3	315.7	126.1	0.0	4920.8
1979	11.1	28.0	98.1	365.5	562.6	440.7	817.7	481.5	871.8	297.0	143.0	0.0	4117.0
1980	5.7	75.9	124.5	272.8	475.3	724.0	799.6	874.9	819.4	385.9	379.7	75.1	5012.8
1981	0.0	34.3	63.7	318.3	400.2	454.3	487.9	238.1	462.1	331.4	335.2	30.9	3156.4
1982	0.0	3.7	23.5	321.1	447.4	197.0	1006.5	864.1	457.8	259.0	229.5	47.2	3856.8
1983	9.4	0.0	128.6	25.1	752.6	468.9	590.4	600.1	872.7	496.9	263.5	25.8	4234.0
1984	37.7	25.7	109.0	381.4	417.1	736.5	337.5	521.2	538.9	374.6	168.5	113.9	3762.0
1985	33.0	161.0	166.1	172.8	477.8	478.6	182.8	632.7	392.7	698.3	144.1	42.2	3582.1
1986	0.0	12.7	22.0	384.5	690.4	332.9	592.4	1023.5	1290.8	455.0	287.1	0.0	5091.3
1987	31.2	27.8	43.4	242.9	395.8	426.0	163.1	802.7	338.9	414.6	232.0	60.8	3179.2

Source : Meteorological Department

Table A1-1-5 : Monthly Rainfall at Thap Put

Code; RM 3704
Station; Amphur Thap Put, Phang Nga

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1956	26.5	39.4	153.2	158.5	334.6	563.0	350.5	668.0	769.7	473.7	169.4	7.8	3714.3
1957	34.2	13.7	50.9	99.1	348.3	297.3	467.6	341.4	299.9	161.5	131.0	6.5	2251.4
1958	6.1	48.5	0.0	54.0	83.6	137.4	202.6	344.2	310.4	265.5	47.1	0.0	1499.4
1959	-	0.0	88.0	110.8	126.3	152.8	227.1	218.0	247.5	199.7	117.0	0.0	-
1960	0.0	0.0	86.5	0.0	139.3	145.3	163.2	147.5	101.1	115.9	94.2	8.4	1001.4
1961	0.0	15.5	14.7	22.4	49.8	110.2	10.9	8.2	27.3	68.8	31.7	13.6	373.1
1962	5.9	10.9	16.0	26.2	71.1	71.6	130.6	131.2	184.0	378.7	79.4	46.5	1152.1
1963	52.1	11.6	54.9	58.8	175.4	268.3	72.2	137.2	245.2	202.6	133.1	21.8	1433.2
1964	20.3	72.1	18.2	162.6	532.8	105.8	78.5	374.3	503.9	237.6	146.6	158.0	2410.7
1965	-	-	-	-	-	-	-	-	-	-	-	-	-
1966	56.5	24.0	112.6	270.0	289.0	166.9	346.0	257.2	183.5	478.8	312.2	392.5	2889.2
1967	1.8	0.0	0.0	151.3	369.2	389.5	471.8	407.1	314.4	539.1	81.0	0.0	2725.2
1968	-	0.0	27.5	353.4	409.3	346.9	280.3	553.1	185.6	245.0	78.7	62.7	-
1969	121.1	67.6	156.9	113.9	228.5	380.6	264.5	107.7	717.3	371.2	159.1	73.8	2762.2
1970	87.9	80.3	283.8	180.1	171.2	332.5	314.7	244.9	236.7	241.2	201.4	70.9	2445.6
1971	0.0	167.4	116.6	113.6	255.7	394.9	147.7	79.6	178.3	352.4	77.3	44.7	1928.2
1972	2.1	52.1	262.4	389.1	106.6	229.9	272.8	255.4	262.3	292.2	153.6	75.2	2353.7
1973	21.1	18.2	72.0	206.3	252.0	337.7	412.7	346.6	242.1	355.0	147.4	0.0	2411.1
1974	97.4	0.0	95.7	207.5	260.8	105.7	159.0	339.7	225.6	246.2	202.9	-	-
1975	253.6	-	80.6	147.0	183.4	607.8	190.4	103.8	354.5	357.6	195.9	68.2	-
1976	0.0	0.0	146.6	176.8	160.9	118.7	244.2	149.3	345.9	220.4	130.3	0.0	-
1977	-	39.9	24.7	49.6	401.1	163.8	158.7	332.3	402.4	276.9	84.0	49.5	-
1978	46.5	22.5	59.1	166.8	422.5	330.1	457.2	348.0	168.8	230.0	178.7	8.3	2438.5
1979	29.3	12.8	58.3	213.3	263.1	244.4	590.5	250.5	567.7	265.2	136.5	0.0	2631.6
1980	-	139.5	64.0	257.8	305.5	389.1	520.4	425.7	342.7	203.4	210.4	83.0	-
1981	24.6	24.2	43.5	189.5	251.1	549.1	102.2	116.5	170.2	221.9	199.0	55.2	1947.0
1982	0.0	22.4	108.8	266.4	191.1	155.3	543.5	325.9	0.0	230.8	154.6	23.1	2021.0
1983	27.7	0.0	123.0	48.1	398.0	227.6	-	235.5	396.6	264.5	135.8	14.2	-
1984	83.9	71.9	58.7	234.2	130.7	385.5	194.4	299.9	181.3	150.2	0.0	46.0	1836.7
1985	0.0	4.8	30.7	162.3	153.2	222.6	5.0	213.0	190.3	253.6	158.4	27.5	1421.4
1986	44.0	0.0	28.8	352.8	368.3	241.8	241.3	360.1	537.8	68.5	24.4	12.8	2280.6
1987	75.9	37.9	155.4	94.6	65.5	170.2	58.1	348.8	212.1	325.6	234.2	82.5	1860.8

Source : Meteorological Department

APPENDIX A-2-1

Hydrological Data

2 Hydrological Data

Table A2-2-1 : Monthly Flow Records at Huai Chong Lom

River : Huai Chong Lom   Location : Phang Nga   Station : X-57   Drainage Area : 8 sq m

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
	Streamflow in (MCM)												
1972	-	-	-	-	-	-	0.535	0.752	0.268	0.107	0.005	-	1.667
1973	0.236	0.054	1.322	4.413	3.321	1.777	2.277	2.074	0.348	0.067	0.031	0.029	15.949
1974	0.104	0.991	2.566	0.402	9.696	2.229	3.669	2.877	0.482	0.911	0.097	0.104	24.128
1975	0.544	1.045	7.672	0.509	4.500	1.555	4.098	1.763	0.295	0.163	0.104	0.083	22.331
1976	0.073	3.000	2.696	4.446	2.786	7.750	0.509	1.115	0.348	0.115	0.093	0.083	23.014
1977	0.052	0.589	0.363	-	-	-	2.116	2.022	0.375	0.214	0.194	0.187	6.112
1978	0.259	0.509	1.840	4.714	9.600	7.206	1.634	0.933	0.536	0.321	0.218	0.241	28.011
1979	0.492	1.634	1.296	11.196	7.687	7.024	8.196	1.452	0.696	0.589	0.460	0.562	41.284
1980	0.544	0.643	1.633	6.535	5.866	7.361	2.143	1.555	-	0.643	0.476	0.562	27.961

Table A2-2-2 : Monthly Flow Records at Khlong Sole

River : Khlong Sole   Location : Bang Longthan Phanom   Station : X-58   Drainage Area: 312 sq m

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
	Streamflow in (MCM)												
1972	-	-	-	-	-	119.232	44.725	33.178	14.383	6.850	2.781	2.330	223.479
1973	3.603	7.660	61.949	144.901	103.386	94.349	86.780	52.176	23.490	13.767	9.193	7.660	608.914
1974	11.197	48.747	97.200	60.264	273.197	99.274	152.665	110.678	22.204	20.892	9.072	7.714	913.104
1975	6.273	17.811	188.179	-	129.635	56.765	127.760	56.246	13.312	6.750	4.016	4.607	611.354
1976	6.558	78.852	70.761	122.296	89.057	188.101	29.382	26.931	13.526	7.526	5.738	7.017	645.745
1977	2.600	16.579	18.896	26.730	161.775	-	52.229	36.288	12.910	7.660	5.032	6.160	346.859
1978	4.977	22.124	111.015	149.455	231.521	201.761	105.154	0.989	13.365	7.446	4.306	2.518	854.631
1979	18.377	56.541	59.227	216.067	152.321	130.761	145.625	20.658	12.910	8.812	5.879	6.937	834.115
1980	8.217	21.374	67.288	170.721	173.051	186.313	97.387	69.595	34.364	18.990	11.526	7.901	866.727
1981	10.420	28.364	131.544	65.970	43.578	78.745	50.354	73.120	30.694	17.169	10.040	8.544	548.542
1982	15.993	27.748	41.679	193.970	148.410	138.698	66.103	41.835	26.409	18.668	12.580	11.678	743.771
1983	8.217	38.917	81.596	102.904	157.570	128.123	130.920	70.762	28.177	19.258	13.983	11.517	791.944

Table A2-2-3 Monthly Flow Records at Bang Son

Location; Ban Bang Son Drainage Area; 361 km²

Stream Flow in (MCM)

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
1973	10.70	26.00	51.70	123.00	127.00	121.00	157.00	165.00	58.00	17.00	8.03	8.18	872.60
1974	4.32	25.80	21.20	13.80	72.70	35.50	69.50	67.80	23.90	9.15	5.12	2.94	351.70
1975	14.70	19.80	90.60	26.20	52.60	39.50	52.30	58.50	14.30	51.30	10.40	7.00	437.20
1976	4.61	27.10	24.50	46.40	30.10	87.30	21.20	34.70	12.00	6.33	3.45	4.40	302.20
1977	1.57	11.00	7.71	7.35	39.40	53.00	43.20	31.20	9.40	6.09	3.57	1.90	215.00
1978	4.84	19.40	25.00	45.30	78.50	68.80	38.30	17.80	6.98	5.26	2.57	3.37	316.90
1979	14.70	29.10	23.20	112.00	89.40	69.30	108.00	20.40	10.80	3.84	2.01	1.93	484.70
1980	6.43	9.82	20.30	52.30	62.10	84.60	49.50	48.90	25.00	3.68	2.91	3.04	368.60
1981	4.18	12.40	49.60	13.00	6.54	19.80	22.60	39.30	24.20	7.80	4.69	2.54	206.70
1982	4.74	10.70	8.93	58.40	34.00	37.90	23.00	21.10	9.00	5.91	2.34	2.46	217.50
1983	0.79	19.10	23.20	26.50	40.00	43.80	58.50	36.40	9.81	4.37	1.86	1.78	266.10

Table A2-2-4 Monthly Flow Records at Bang Son

Location; Ban Hin Phn Drianage Area ; 171 km²

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Annual
1973	0.22	0.58	1.69	5.98	4.12	3.83	7.12	6.76	2.74	0.46	0.13	0.22	79.39
1974	0.32	1.24	0.65	0.59	2.43	3.51	5.13	9.28	4.85	1.31	0.54	0.31	30.16
1975	2.14	2.83	11.80	5.30	7.02	5.66	8.69	8.60	2.54	8.79	2.39	1.35	67.11
1976	2.20	10.60	13.00	22.30	18.80	49.70	25.20	30.30	13.10	6.14	2.67	2.88	196.89
1977	0.14	1.16	0.47	1.11	2.02	4.41	6.56	5.13	1.70	0.82	0.29	0.14	23.95
1978	0.11	4.92	3.47	5.43	4.56	3.76	7.02	2.76	0.96	0.60	0.16	0.18	33.93
1979	1.33	3.01	2.87	16.20	10.20	11.80	12.40	4.01	1.64	0.47	0.15	0.31	64.39
1980	1.06	0.91	2.81	7.02	7.52	9.02	8.93	6.30	3.73	0.91	0.36	0.31	48.88
1981	0.41	1.62	5.23	1.33	0.47	2.91	4.52	7.68	4.77	1.16	0.86	0.34	31.30
1982	0.51	1.83	3.813	10.20	5.91	2.99	5.73	5.94	2.64	0.80	0.23	0.16	40.75
1983	0.13	1.61	2.896	1.81	5.41	6.05	6.89	4.05	1.48	0.91	0.26	0.28	31.77

APPENDIX A-2-2

Runoff Analysis

Runoff Analysis

Rainfall Synthesis

The daily rainfall data for the six gauging stations, collected from the Meteorological Department, RID and NEA within and around the vicinity of the study area, contain many missing data. To generate such missing data, correlation study was done on the basis of monthly rainfall using the overlapping observation periods of the stations.

The coefficients of correlation and equations of linear regression employed to synthesize the missing rainfall data in the object stations were determined statistically by means of the method of least square on a monthly basis among stations.
The highest correlation was taken to complement the missing rainfall data and generation of daily rainfall was done following the procedures shown below;

a) Equation of linear regression obtained through the correlation study is expressed as:

$$Y = aX + b$$

where X: Monthly rainfall at the key station which keeps perfect daily record of rainfall during period under consideration

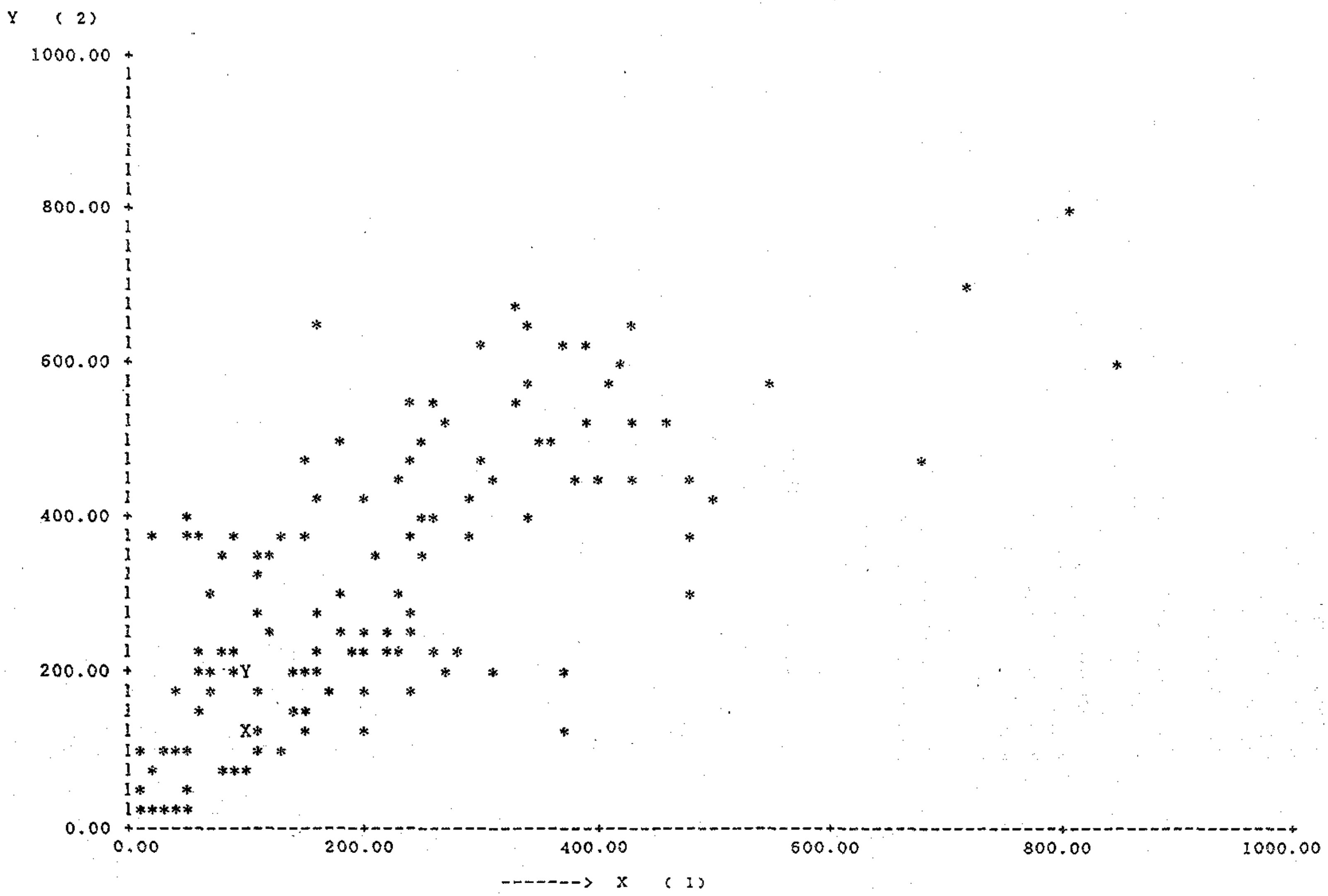
Y: Expected monthly rainfall at the object station which involves missing data

a,b: Coefficient and constant

***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN PHANG NGA AND TAKUA THUNG *****

1973--1987

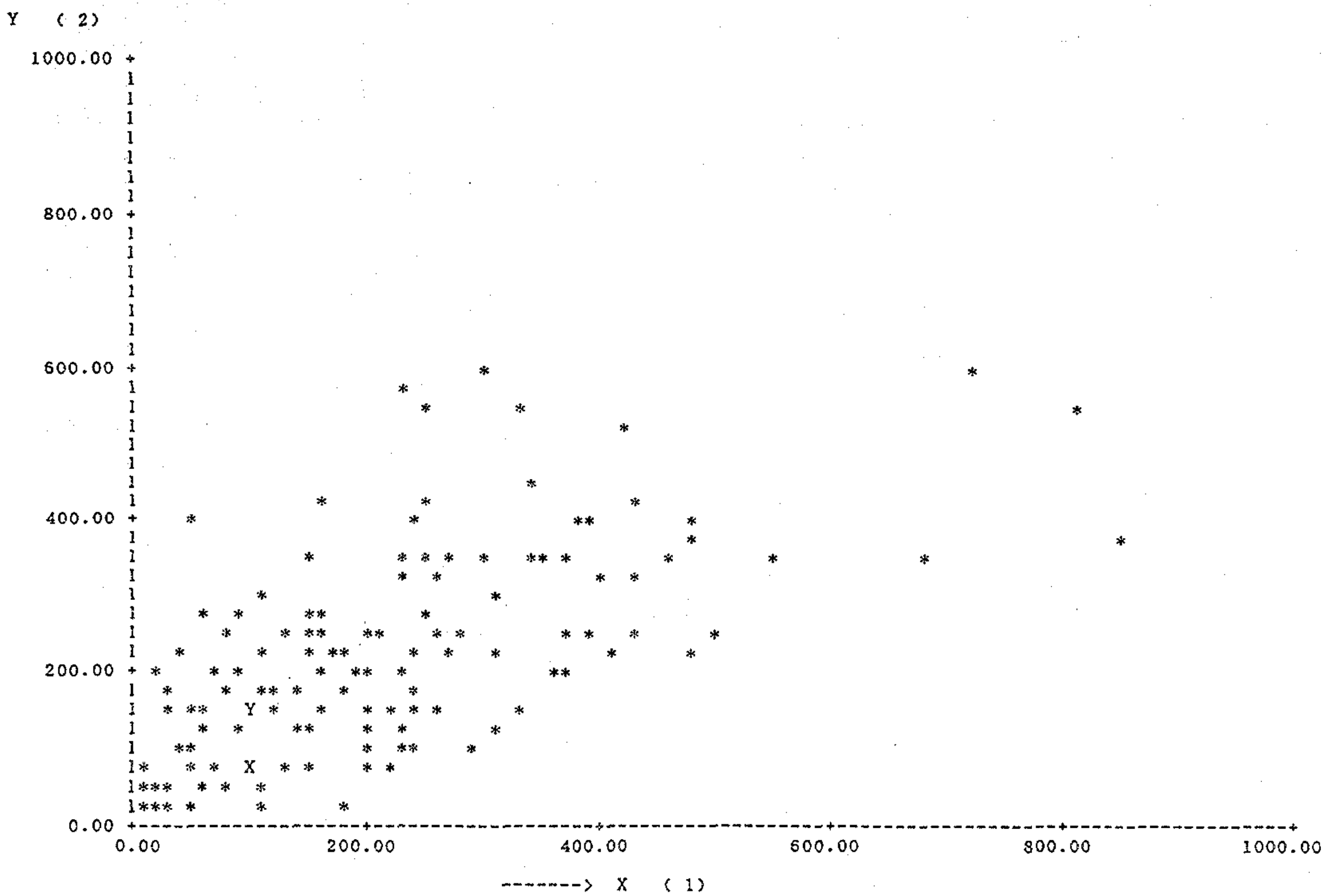
```
Y =     0.839 X +   122.297  (      MM          )  R = 0.740
X =     0.654 Y +    11.158  (      MM          )
```



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN PHANG NGA AND THA PUT   *****

1973--1987

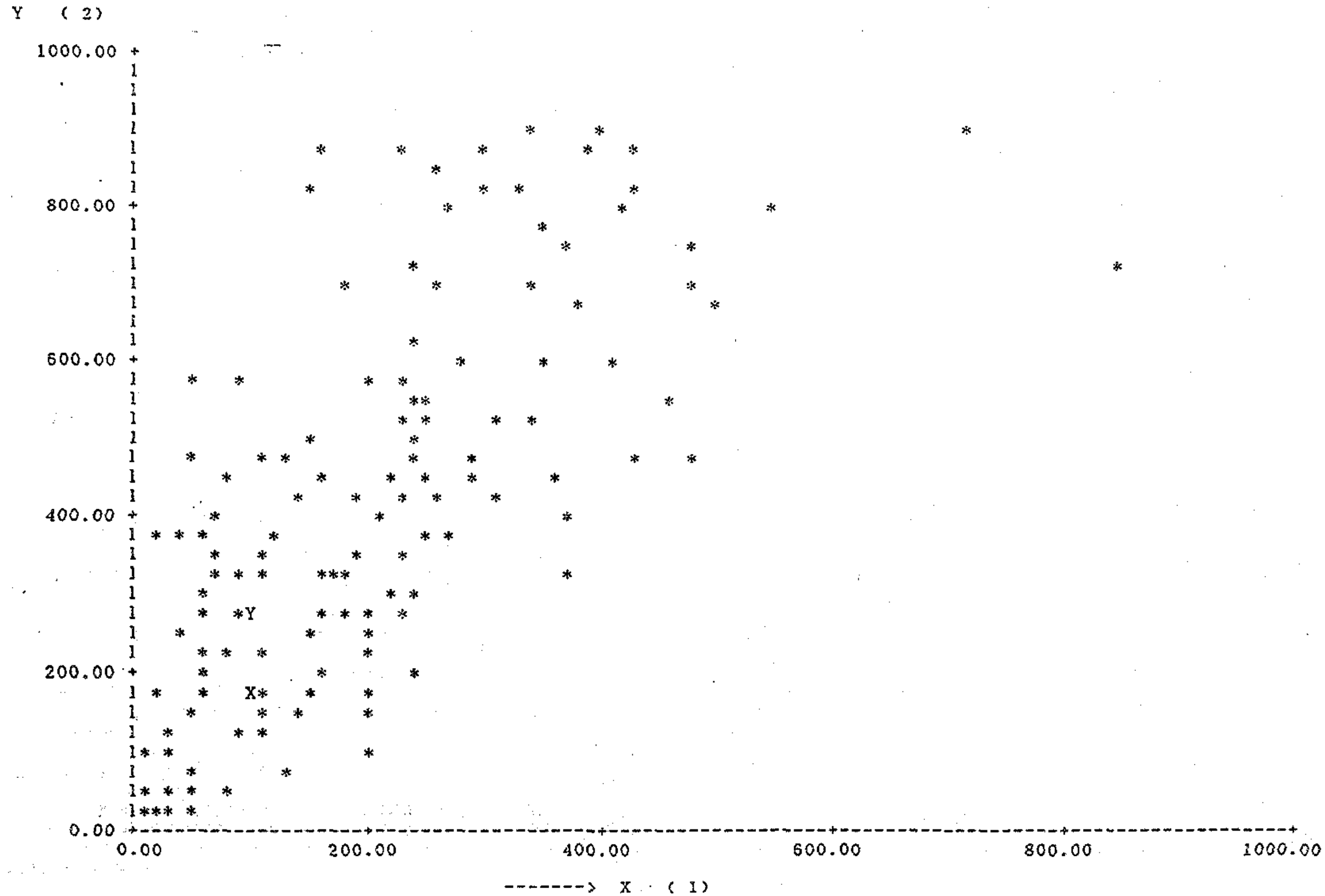
Y = 0.536 X + 105.886 (MM) R = 0.643
X = 0.771 Y + 38.928 (MM)



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN PHANG NGA AND KAPONG *****

1973--1987

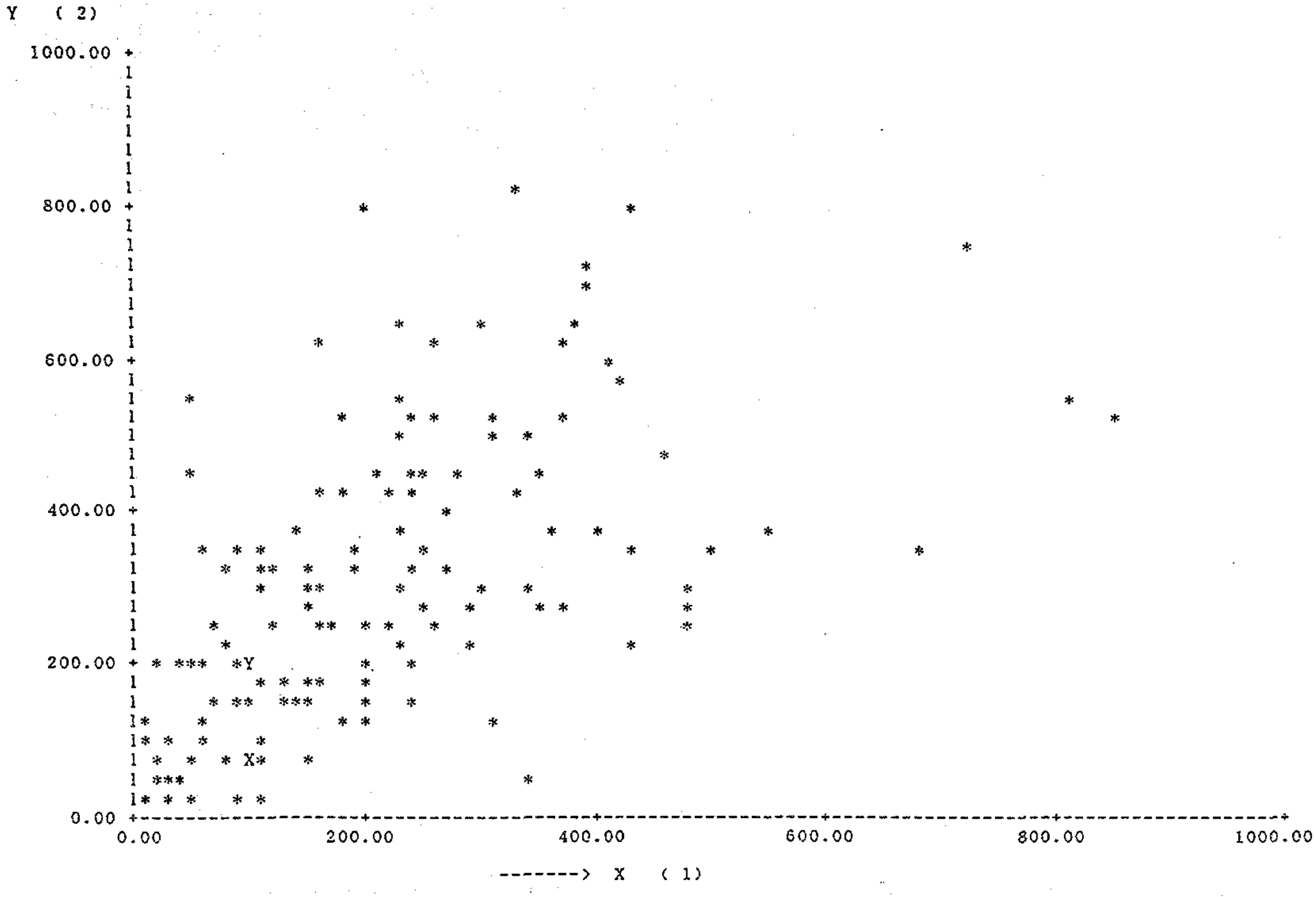
Y = 1.260 X + 146.533 (MM) R = 0.737
X = 0.431 Y + 24.259 (MM)



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN PHANG NGA AND THAI MUANG *****

1973--1987

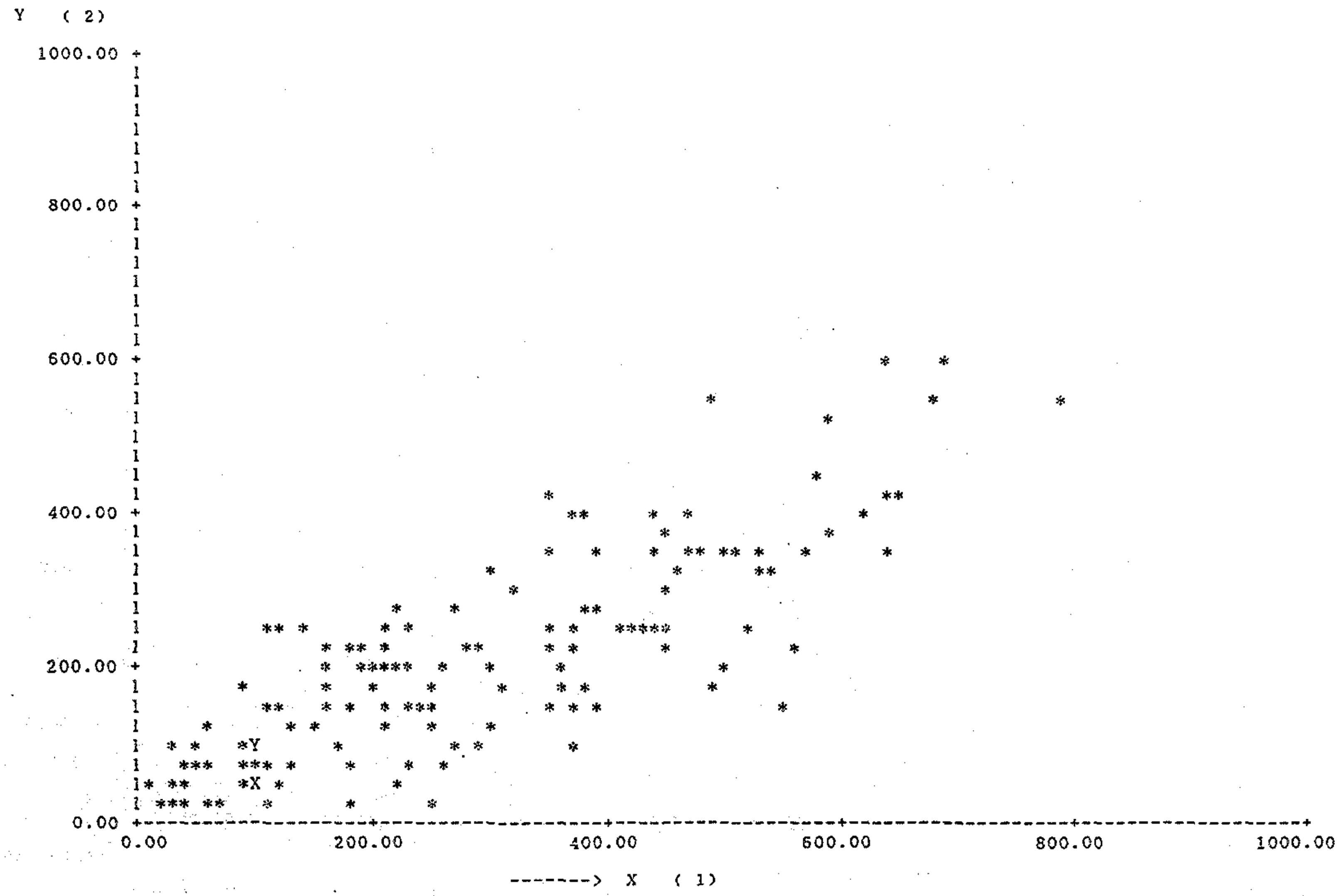
Y = 0.739 X + 137.758 (MM) R = 0.612
X = 0.506 Y + 57.424 (MM)



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN TAKUA THUNG AND TAP PUT *****

1973--1987

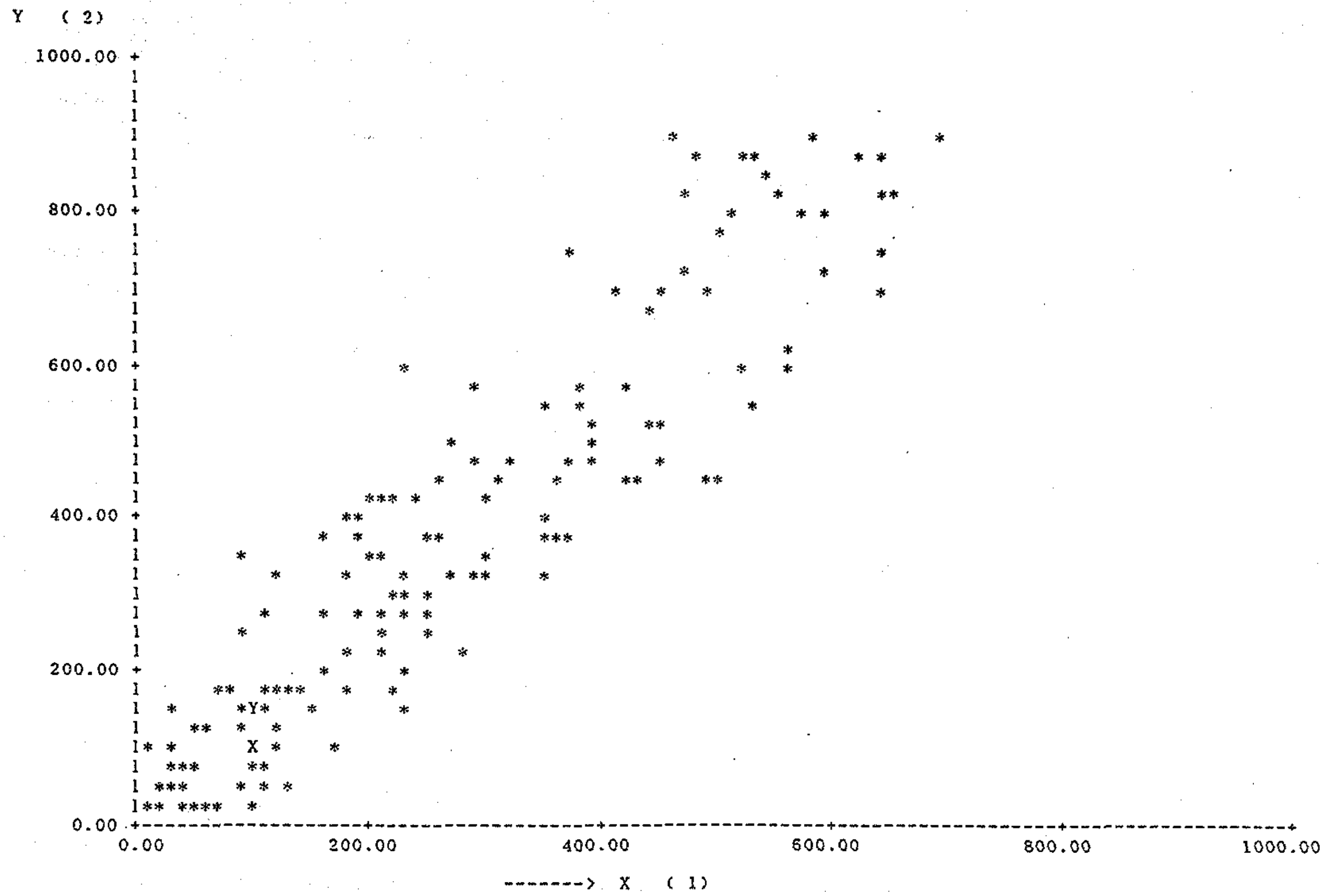
Y = 0.589 X + 38.187 (MM) R = 0.829
X = 1.166 Y + 42.147 (MM)



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN TAKUA THUNG AND KAPONG *****

1973--1987

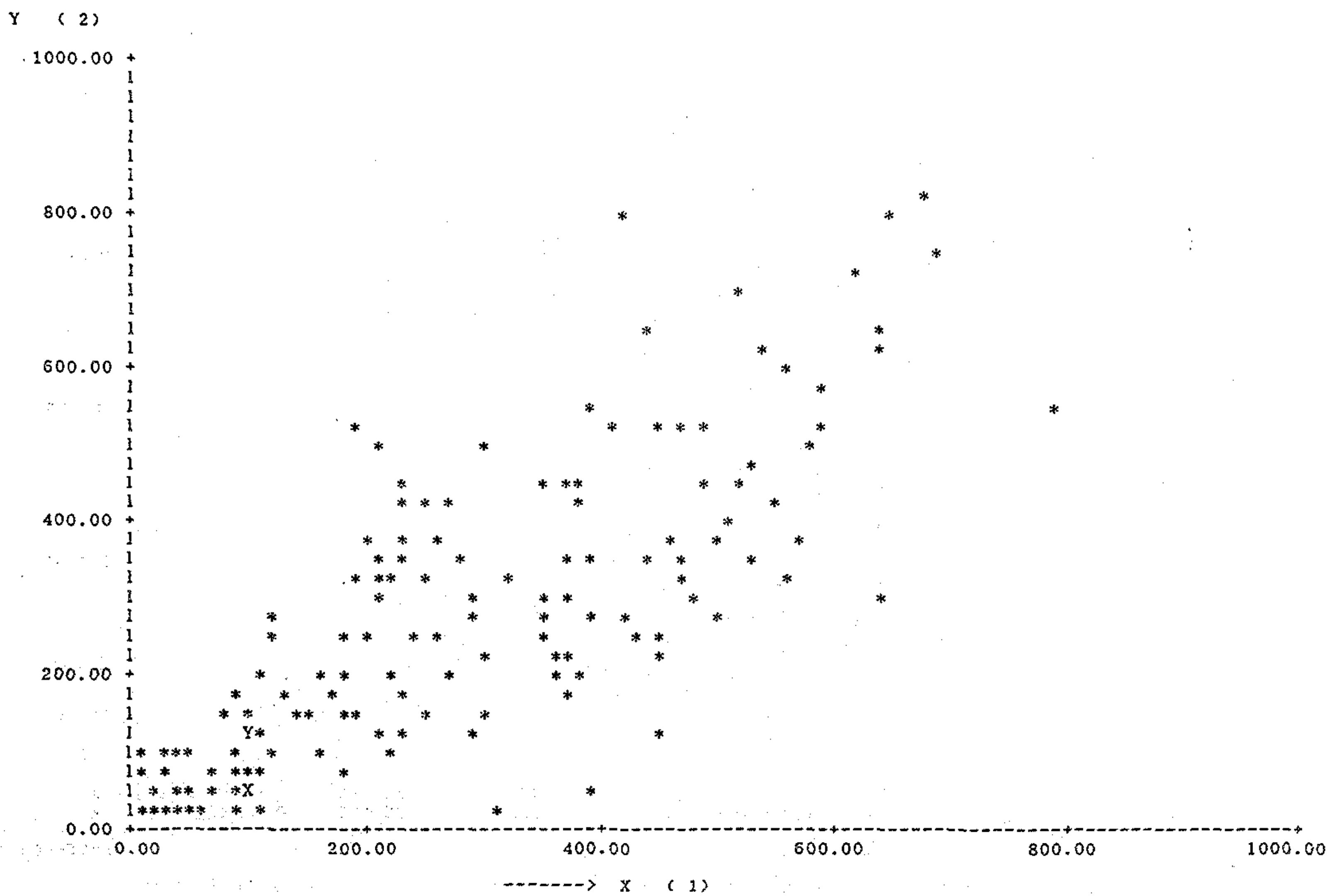
Y = 1.320 X + 11.482 (MM) R = 0.928
X = 0.652 Y + 29.358 (MM)



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN TAKUA THUNG AND THAI MUANG *****

1973--1987

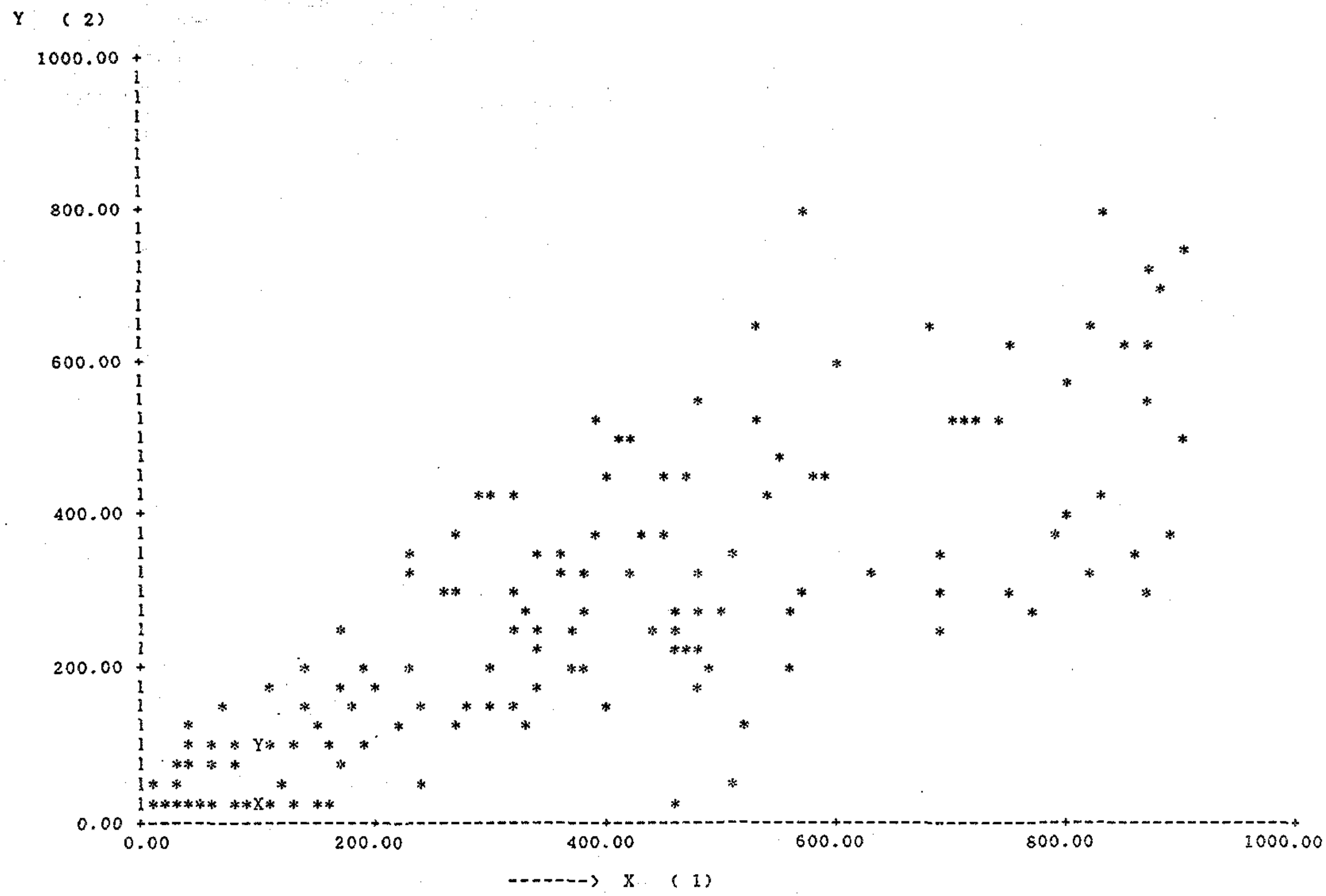
```
Y =    0.857 X +    29.785  (    MM        )  R = 0.816
X =    0.776 Y +    66.094  (    MM        )
```



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN KAPONG AND THAI MUANG *****

1973--1987

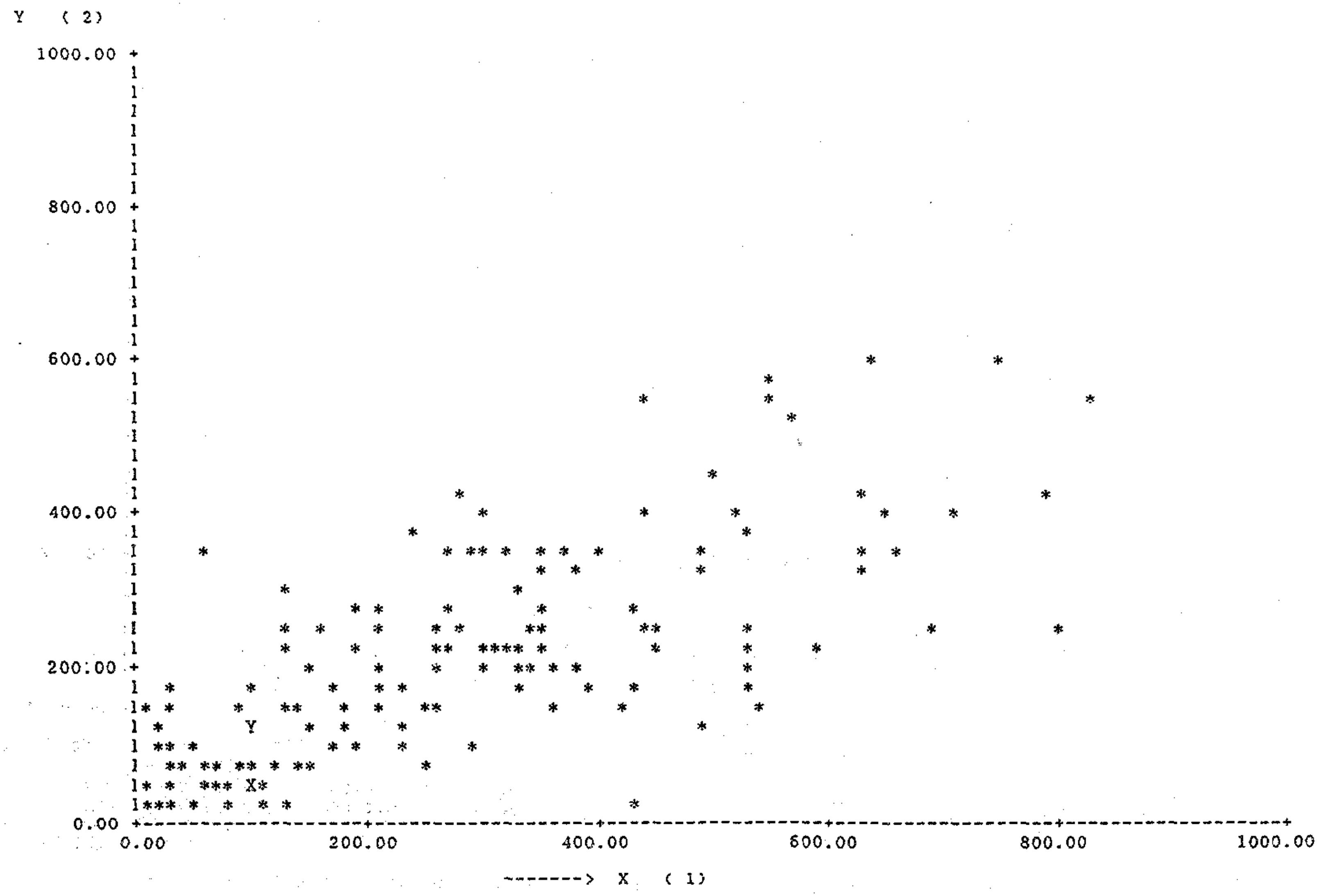
Y = 0.605 X + 38.118 (MM) R = 0.810
X = 1.085 Y + 80.954 (MM)



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN THAI MUANG AND TAP PUT *****

1973--1987

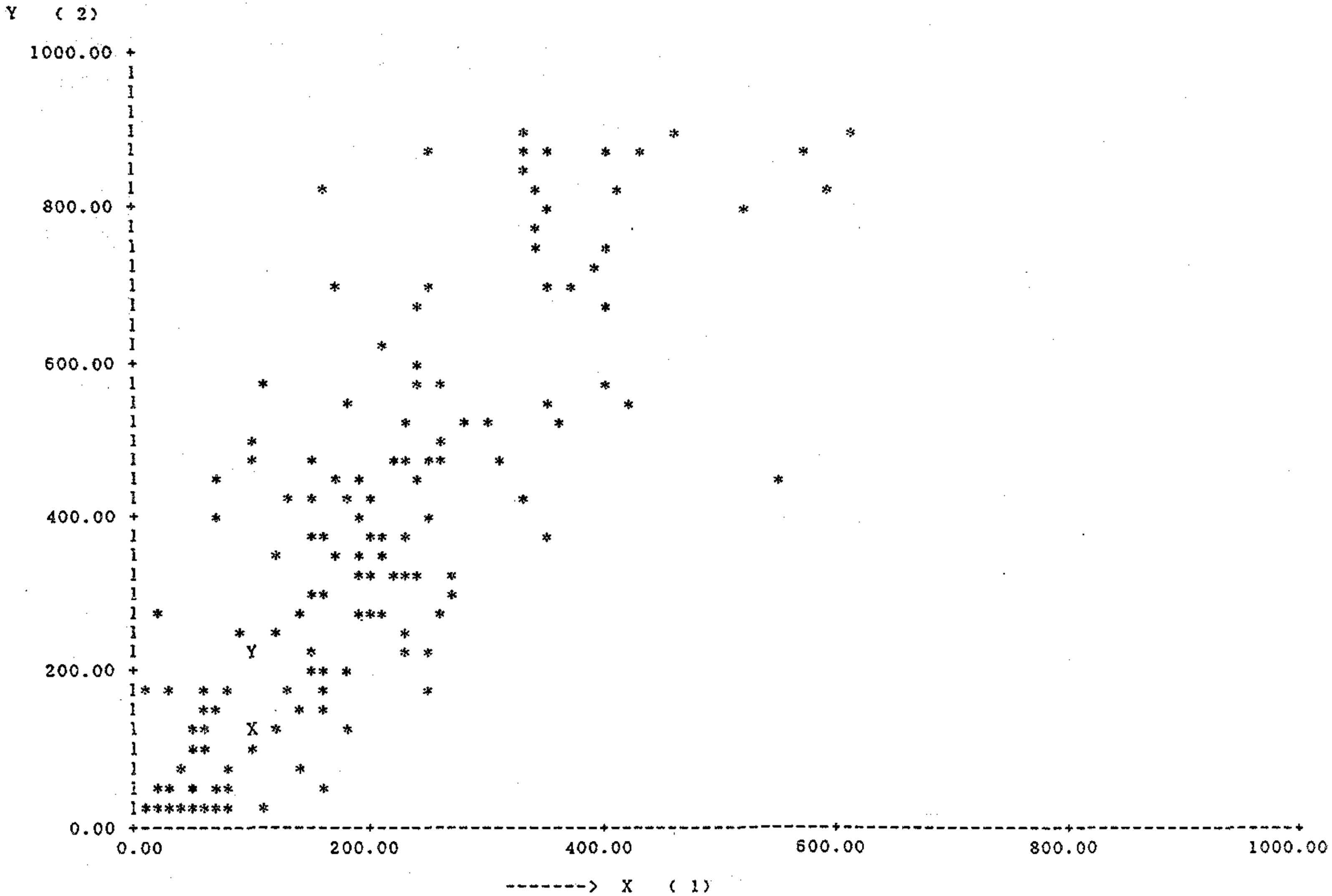
```
Y =    0.503 X +    66.493  (    MM       )  R = 0.739
X =    1.086 Y +    49.902  (    MM       )
```



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN THAP PUT AND KAPONG   *****

1973--1987

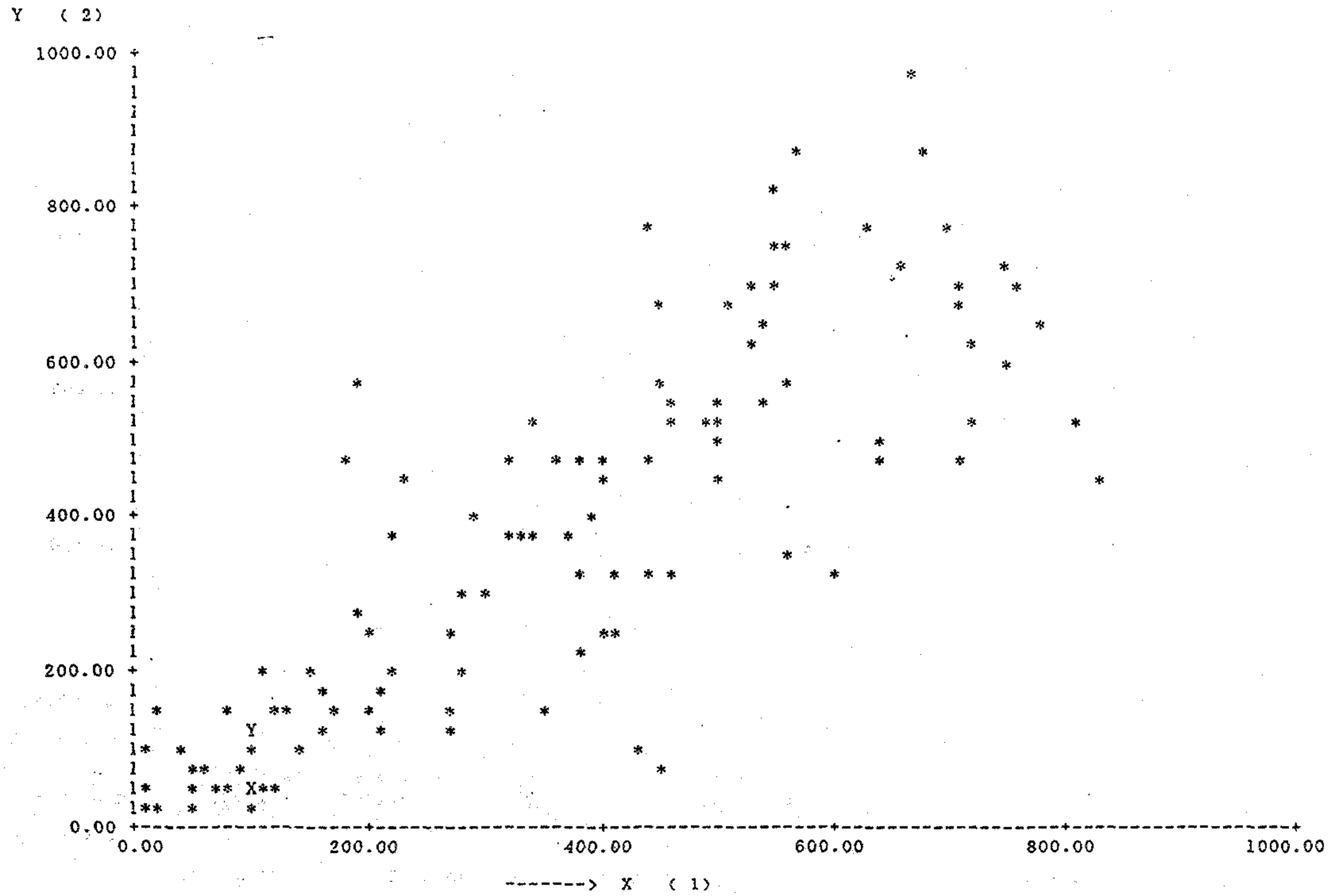
Y = 1.624 X + 50.299 (MM) R = 0.816
X = 0.410 Y + 44.865 (MM)



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN TAKUA PA AND TAKUA PA(MD) *****

1976--1987

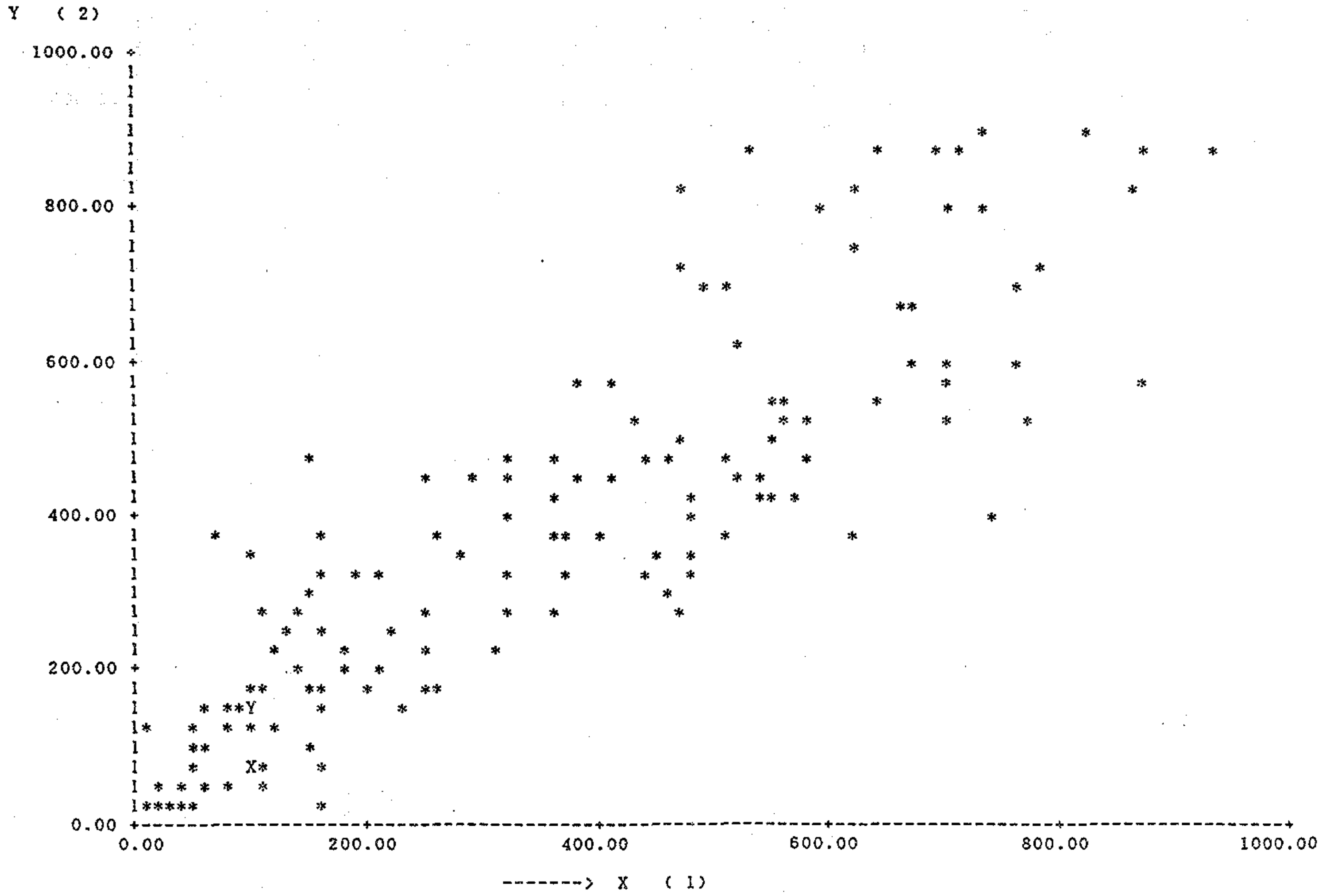
Y = 0.928 X + 29.845 (MM) R = 0.851
X = 0.780 Y + 67.861 (MM)



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN TAKUA PA AND KAPONG *****

1973--1987

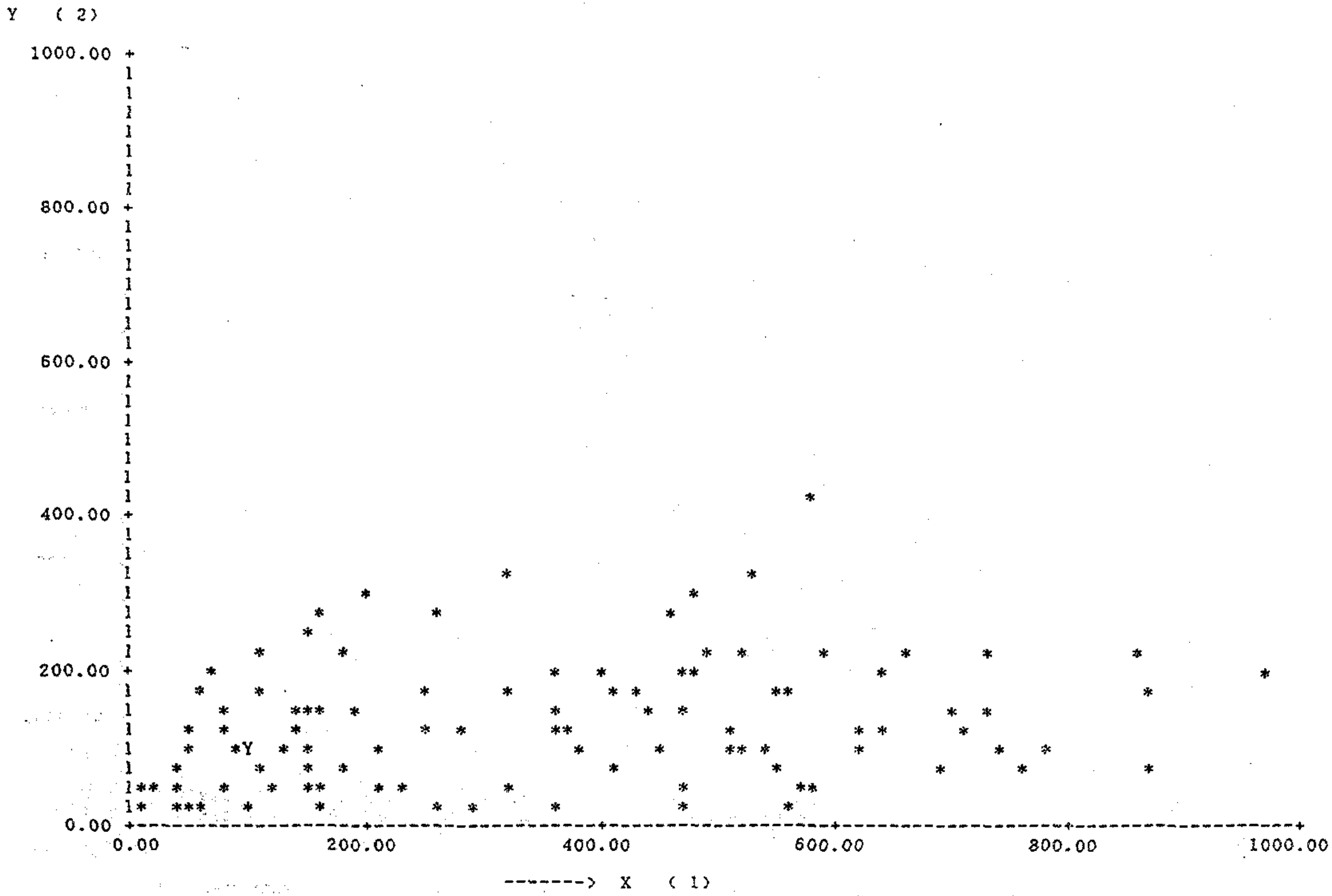
Y = 0.877 X + 62.287 (MM) R = 0.878
X = 0.880 Y + 23.828 (MM)



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN TAKUA PA AND PHANOM *****

1973--1987

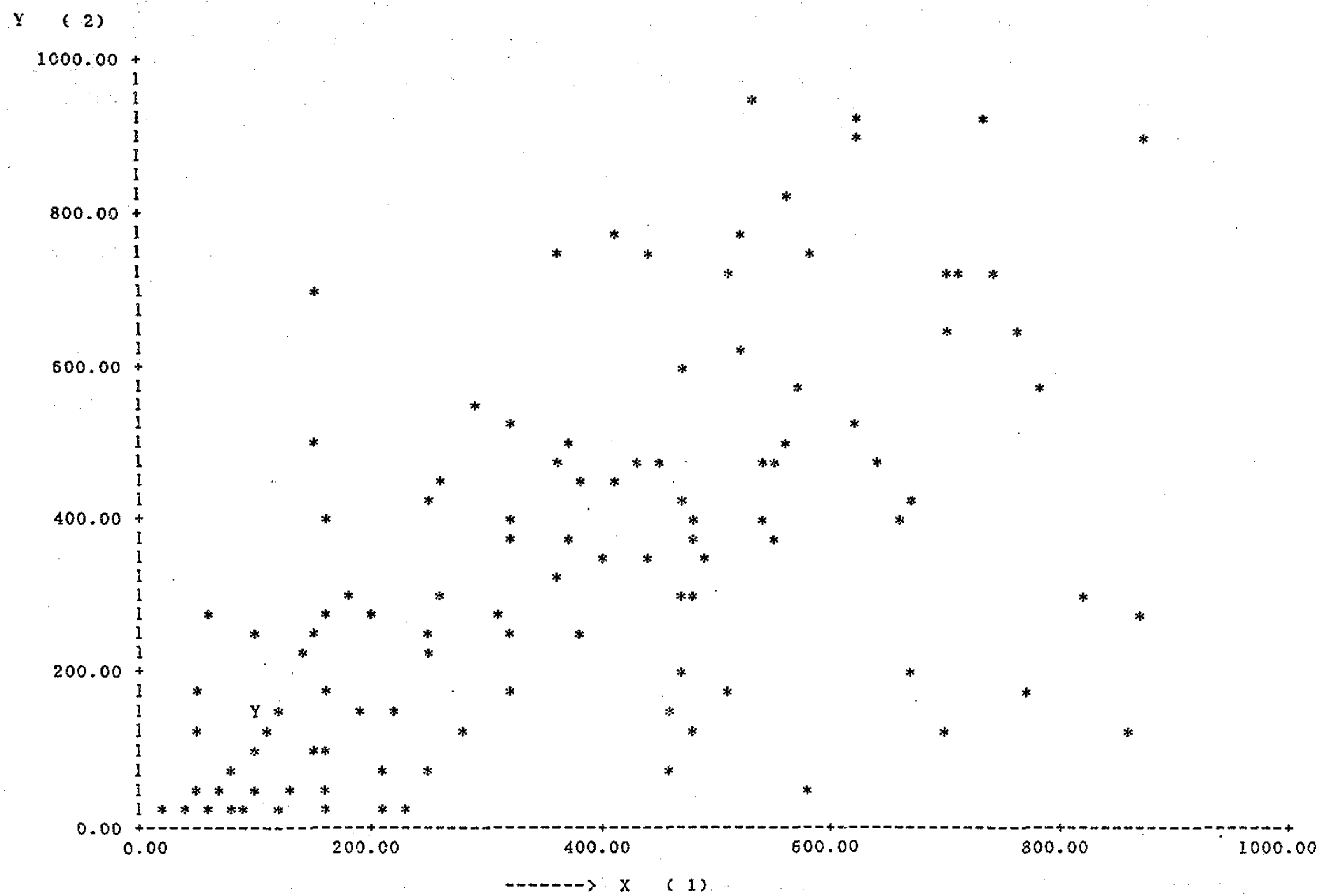
```
Y =     0.100 X +    91.018  (       MM           )  R = 0.283
X =     0.799 Y +   248.384  (       MM           )
```



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN TAKUA PA AND KURA BURI *****

1973--1987

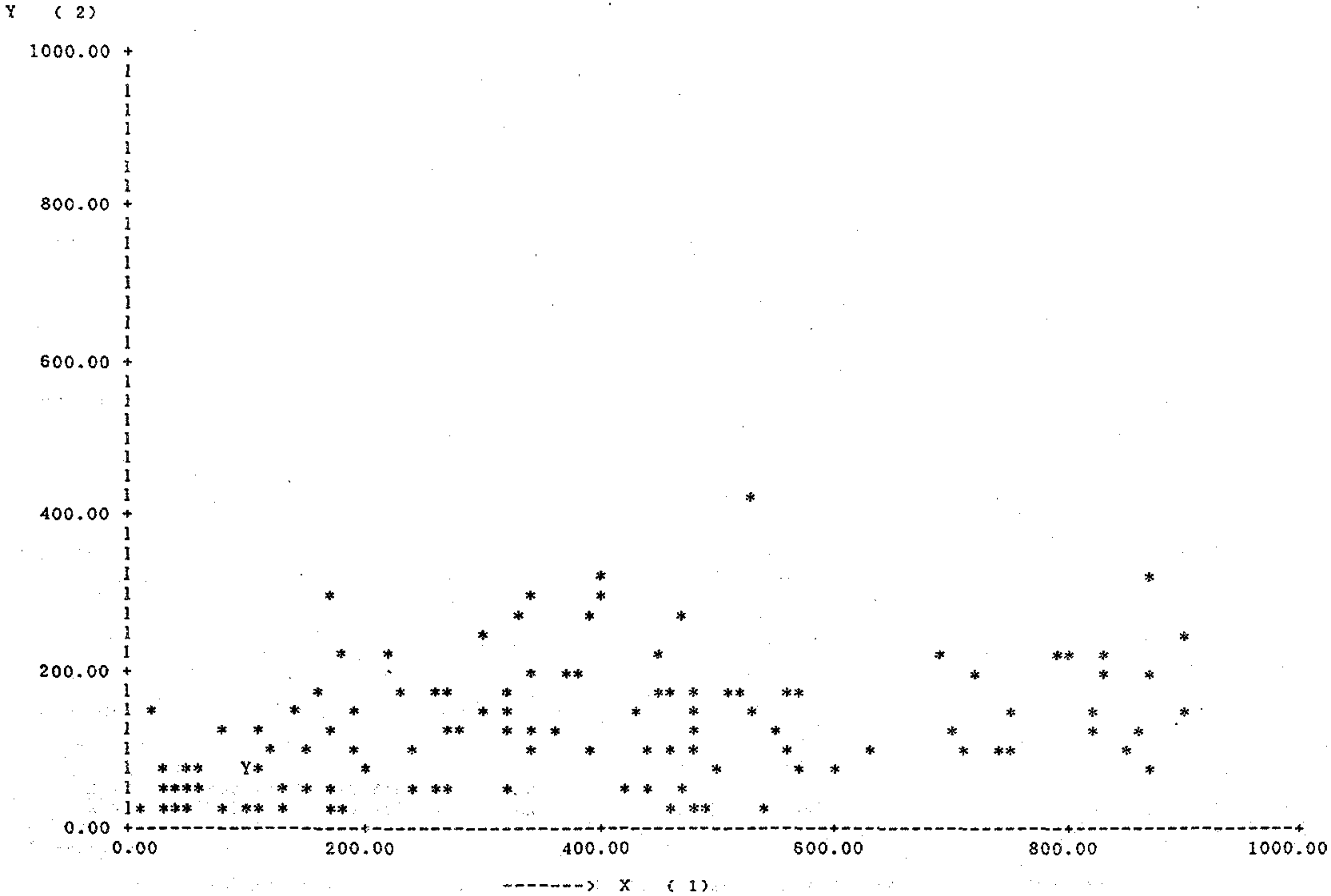
Y = 0.695 X + 77.483 (MM) R = 0.635
X = 0.580 Y + 165.816 (MM)



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN KAPONG AND PHANOM *****

1973--1987

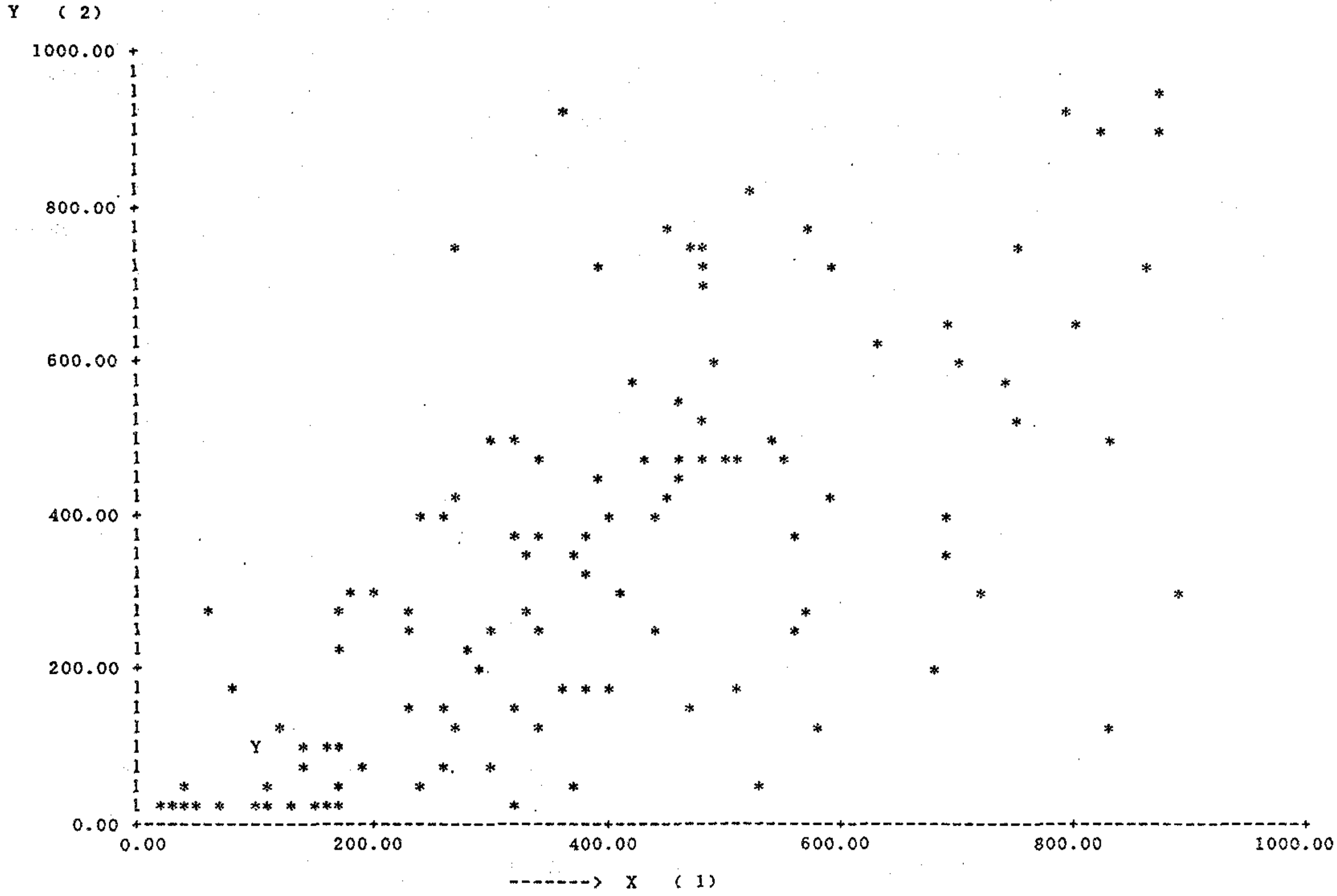
Y = 0.139 X + 69.599 (MM) R = 0.426
X = 1.301 Y + 210.941 (MM)



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN KAPONG AND KURA BURI *****

1973--1987

Y = 0.782 X + 32.732 (MM) R = 0.698
X = 0.623 Y + 169.658 (MM)



***** THE REGRESSION LINE OF CO-RELATION OF RAINFALL BETWEEN PHANOM AND KURA BURI   *****

1973--1987

Y =   0.379 X +   311.301 (MM   ) R = 0.117
X =   0.036 Y +   116.667 (MM   )