

8) System Connection by Income Bracket (Fig-5.3)

To find the relationship between per capita income and individual house-connection ratio, screening of data, which was collected during the questionnaire survey, was made by taking the following steps:

- a) Picking up all families having less than 20 family members,
- b) Picking up all families in the residential-only dwellings and residential-commercial dwellings from selected families in step a),
- c) Classifying the above selected families by per capita income brackets, and
- d) Grouping the classified families whether they have services through individual house connections or not.

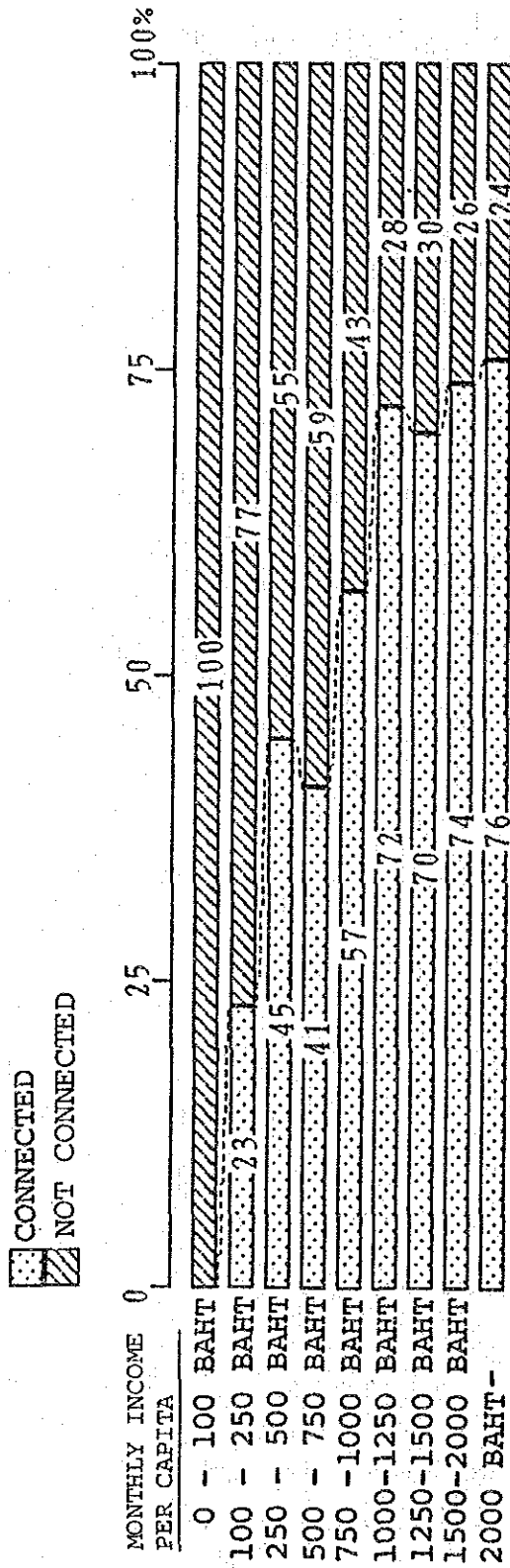
As shown in Fig-5.3, there is an apparent positive correlation between per capita income and individual house connection services. It is also observed that more than 70 % of families whose incomes are higher than 1,000 Baht have PWA services through individual house connections.

#### 5.5.2 Sanitary Districts

The survey results are summarized in Table-5.3 and shown in Fig-5.4 (1) to (6) graphically.

1) Type of Building Surveyed (see Table-5.3 and Fig-5.4 (1))

Of the 893 households answering the captioned question, 74.8 % lived in residential-only (purely residential) buildings while 23.4 % in residential-commercial buildings. Altogether 98.2 %, most of the 893, lived in the residential-purported buildings and consumed water for domestic uses.



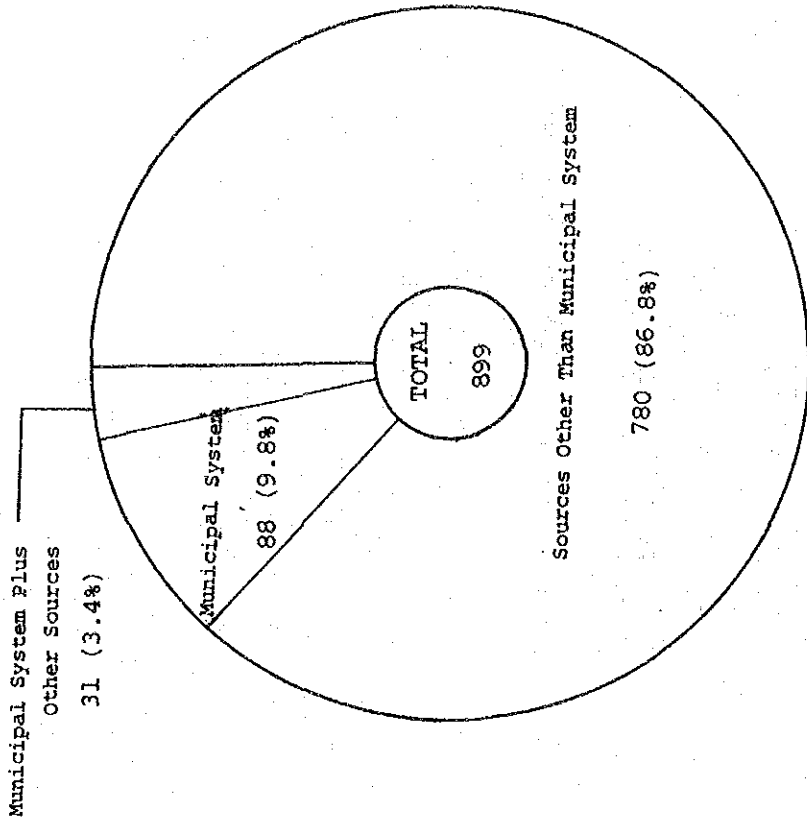
**FIGURE**  
5.3  
SYSTEM CONNECTION BY INCOME BRACKETS  
( CHIANGMAI )  
JAPAN INTERNATIONAL COOPERATION AGENCY

Table-5.3 SURVEY RESULTS

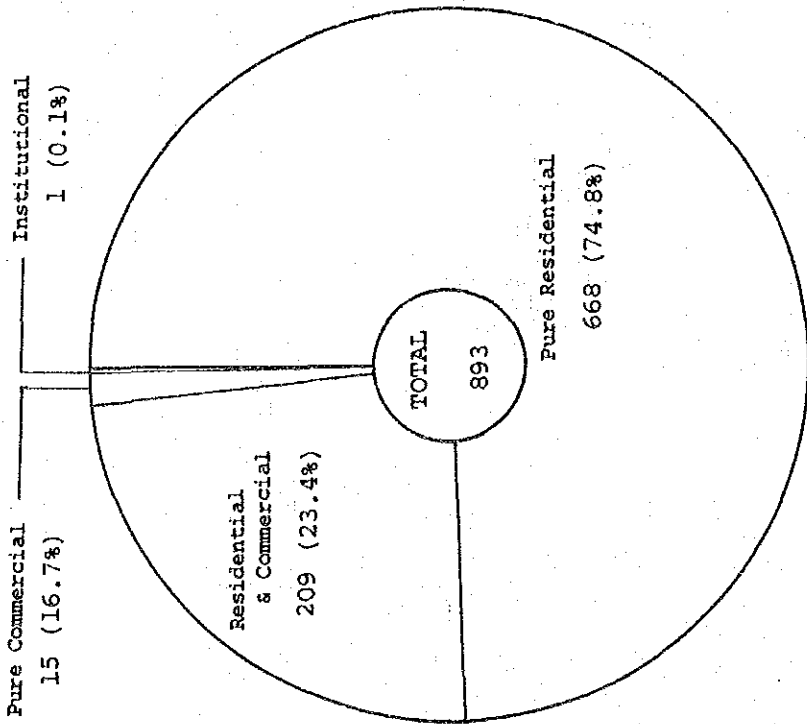
## 5 SANITARY DISTRICTS

QUESTIONNAIRE	TOTAL		
<b>Q-1 :Type of Building Surveyed</b>			
Pure Residential	668	1 :Less than 50 Baht	43
Residential & Commercial	209	2 :50 - 100	35
Pure Commercial	15	3 :100 - 150	13
Institutional	0	4 :150 - 200	7
Industrial	1	5 :200 - 300	6
No Anser	7	6 :300 - 500	5
		7 :500 -1,000	5
		8 :1,000 - 5,000	2
		9 :5,000 - 10,000	0
		10 :Over 10,000	0
		11 :No Answer	3
<b>TOTAL Q-1</b>	<b>900</b>		
<b>Q-2 :Type of Water Supply Sources</b>		<b>TOTAL Q-7</b>	<b>119</b>
A :Municipal System Only	88	<b>Q-8 :Willingness to be Connected</b>	
B :Municipal System Plus Other Sources		1 :Yes	360
B-1 : Rain/River Water	0	2 :No	401
B-2 : Pond / Reservoir Water	0	3 :No Answer	20
B-3 : Water Vender	3		
B-4 : Groundwater	28	<b>TOTAL Q-8</b>	<b>781</b>
B-5 : Combined Sources	0	<b>Q-9 :Willingness to Pay for Water per Month</b>	
C :Sources Other Than Municipal System		1 :Upto 50 Baht	255
C-1 : Rain/River Water	0	2 : 100	70
C-2 : Pond / Reservoir Water	0	3 : 200	12
C-3 : Water Vender	0	4 : 500	1
C-4 : Groundwater	757	5 : 1,000	0
C-5 : Combined Sources	23	6 : 2,000	0
D :No Answer	1	7 : 5,000	0
		8 : 10,000	0
		9 :No Answer	22
Sub total (A + B)	119	<b>TOTAL Q-9</b>	<b>360</b>
Sub total (C)	780	<b>Q-10:Average Monthly Income per Household</b>	
<b>TOTAL Q-2</b>	<b>900</b>	A :Sources Other Than Municipl System	
<b>Q-5 :Current Status of Water Supply (Municipal System)</b>		1 :Less than 2,000 Baht	283
A :Satisfactory	59	2 : 2,000 - 3,000	216
B :Unsatisfactory		3 : 3,000 - 4,500	134
B-1 : Poor Quality	6	4 : 4,500 - 6,000	84
B-2 : Low Pressure	0	5 : 6,000 - 7,500	26
B-3 : Unstable	6	6 : 7,500 -10,000	13
B-4 : Expensive	26	7 : 10,000 -15,000	6
B-5 : Combined Reasons	17	8 : 15,000 -50,000	2
C :No Answer	5	9 :Over 50,000	1
		10 :No Answer	16
<b>TOTAL Q-5</b>	<b>119</b>	Sub total Q-10-A	<b>781</b>
<b>Q-6 :Average Monthly Water Consumption</b>		B :Municipal System Plus Sources	
1 :Less than 15 m3	45	1 :Less than 2,000 Baht	26
2 :15 - 30	47	2 : 2,000 - 3,000	19
3 :30 - 50	8	3 : 3,000 - 4,500	24
4 :50 - 75	9	4 : 4,500 - 6,000	20
5 :75 - 100	1	5 : 6,000 - 7,500	14
6 :100 - 150	4	6 : 7,500 -10,000	7
7 :150 - 200	1	7 : 10,000 -15,000	1
8 :200 - 300	0	8 : 15,000 -50,000	4
9 :Over 300	0	9 :Over 50,000	3
10 :No Answer	4	10 :No Answer	1
<b>TOTAL Q-6</b>	<b>119</b>	Sub total Q-10-B	<b>119</b>
		<b>TOTAL Q-10</b>	<b>900</b>

TYPE OF WATER SUPPLY SOURCE



TYPE OF BUILDING SURVEYED



**FIGURE** QUESTIONNAIRE SURVEY RESULTS ( 1 )  
5.4 (1) ( SANITARY DISTRICTS )

2) Type of Water Supply Sources (see Table-5.3 and Fig-5.4 (1), (2))

Of the 899 households answering the captioned question, 9.8 % used the municipal system only, 3.4 % the municipal system and other sources and 86.8 % other sources only. (Fig-5.2 (1))

The reason for the small percentage of those receiving PWA services is that PWA services are now being offered to only two sanitary districts, i.e., Mae Rim and San Kamphaeng, out of the five.

Fig-5.4 (2) shows how the other sources were used. When the two graphs are combined, the groundwater's share is the largest, 785 of the total 811, or 96.8 %.

Of the 899 interviewees who responded to the captioned question, 84.2 % were using groundwater.

3) Current Status of Water Supply (Table-5.3, Fig-5.4 (3))

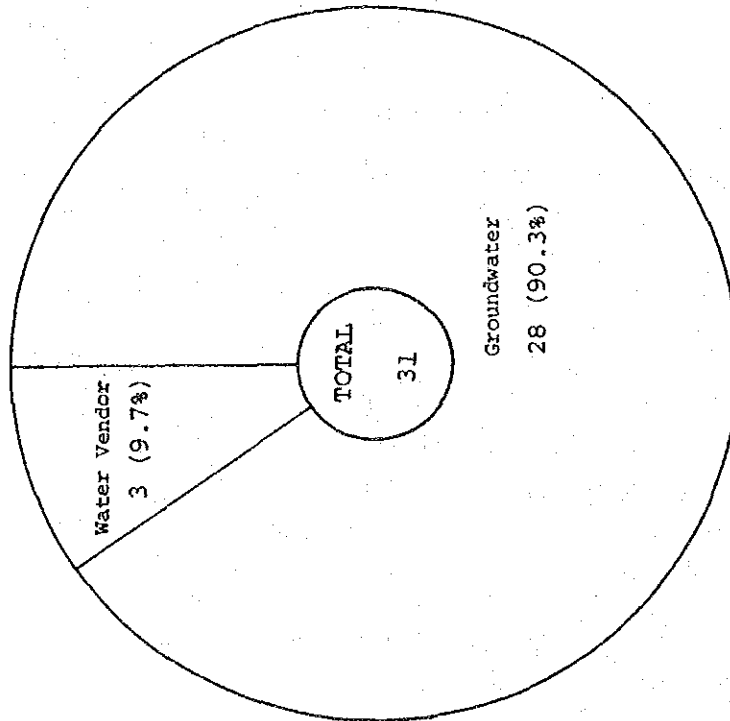
Of the 114 households using the PWA system wholly or partly, 48.2 % were found to be dissatisfied with the service. Of the reasons, 47.3 % of the 55, pointed out costliness, 30.9 % combined reasons, 10.9 % instability of the supply condition and poor quality.

4) Monthly Average Consumption and Payment (Table-5.3, Fig-5.4 (4))

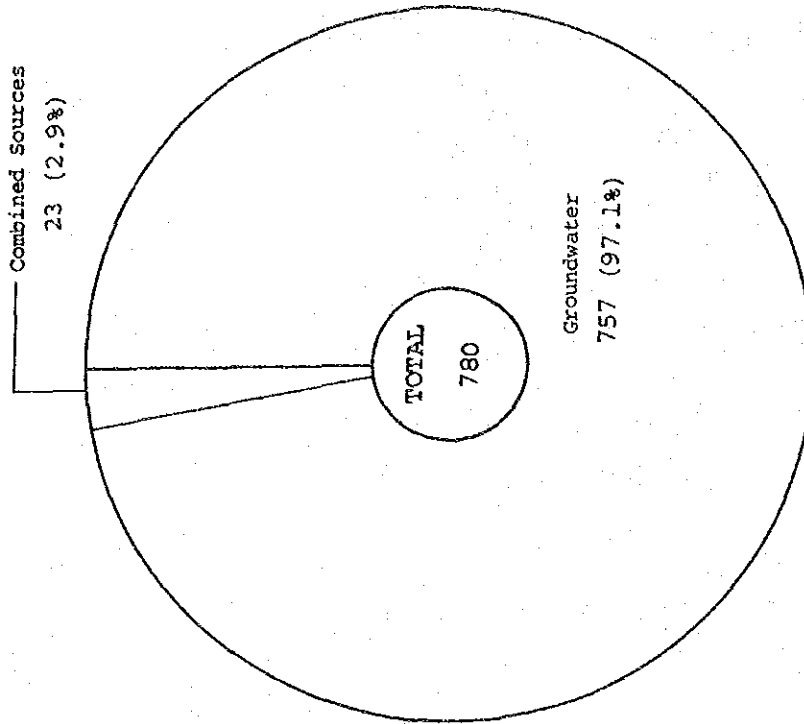
Consumption and payment are closely related. Of the 115 households surveyed, the less-than-15 cu m/month consumer, numbering 45 and sharing 39.1 %, corresponds the less-than 50 Baht payer, numbering 43 and sharing 37.1 %. Likewise, 15-30 cu m/month consumer correspond the payer of 50-150 baht.

It also indicates that a limit in economizing consumption and payment exists at the low level.

MUNICIPAL SYSTEM PLUS OTHER SOURCES



SOURCES OTHER THAN MUNICIPAL SYSTEM



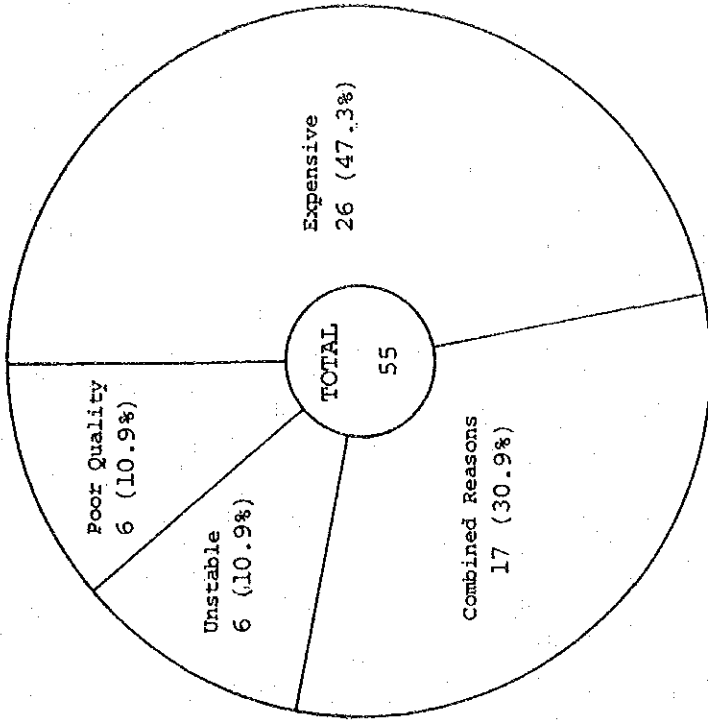
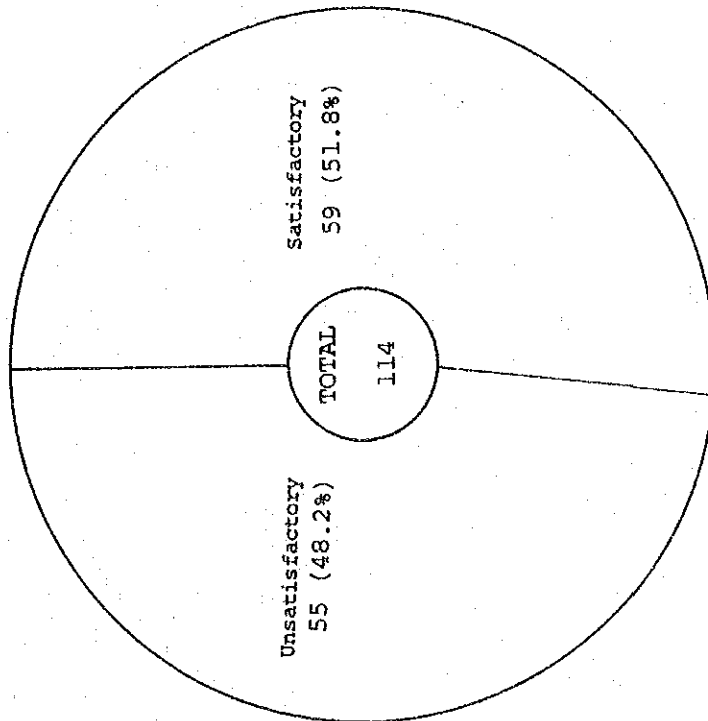
FIGURE

QUESTIONNAIRE SURVEY RESULTS ( 2 )

5.4(2)

( SANITARY DISTRICTS )

CURRENT STATUS OF WATER SUPPLY  
MUNICIPAL SYSTEM



**FIGURE**

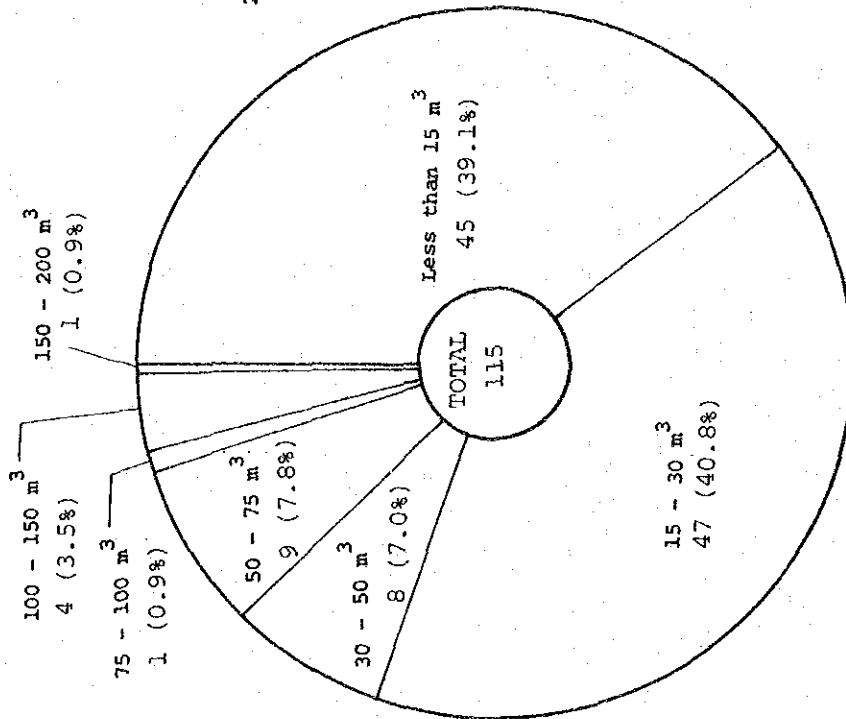
QUESTIONNAIRE SURVEY RESULTS ( 3 )

5.4(3)

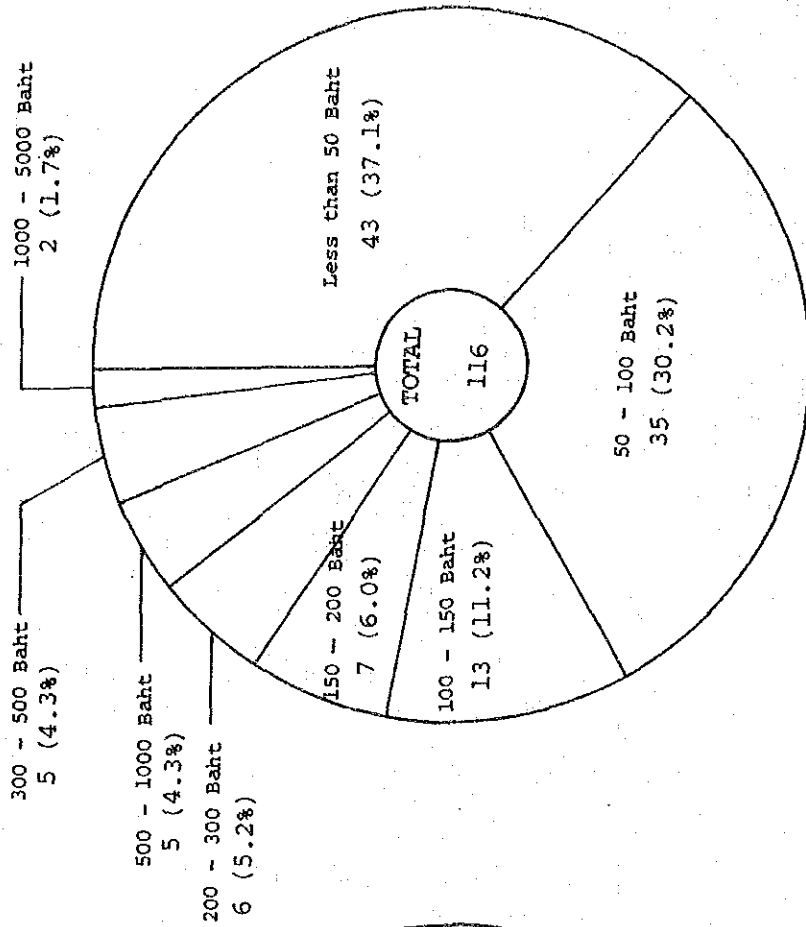
( SANITARY DISTRICTS )

JAPAN INTERNATIONAL COOPERATION AGENCY

MONTHLY AVERAGE WATER CONSUMPTION



AVERAGE COST OF WATER PER MONTH



FIGURE

QUESTIONNAIRE SURVEY RESULTS ( 4 )

5.4 (4)

( SANITARY DISTRICTS )



5) Willingness to be connected to Municipal System  
(Table-5.3, Fig-5.4 (5))

By the people using sources other than the Municipal system, the captioned question was answered.

Of the 761 interviewees who are not receiving PWA services, 52.7 % are not willing to be connected with the PWA water system. Their breakdown is shown below.

Willingness to be connected

	No. of Interviewees	Yes (%)	No (%)
Mae Rim	93	49.5	50.5
San Kamphaeng	107	49.5	50.5
San Sai	222	64.4	35.6
Saraphi	189	29.6	70.4
Hang Dong	150	41.3	58.7

Among the five sanitary districts, percentages of willingness for Hang Dong and Saraphi are relatively low. Particularly in Saraphi, merely 29.6 % of the interviewees have a willingness to be connected. This may reflect comparatively good water quality of the groundwater in the area.

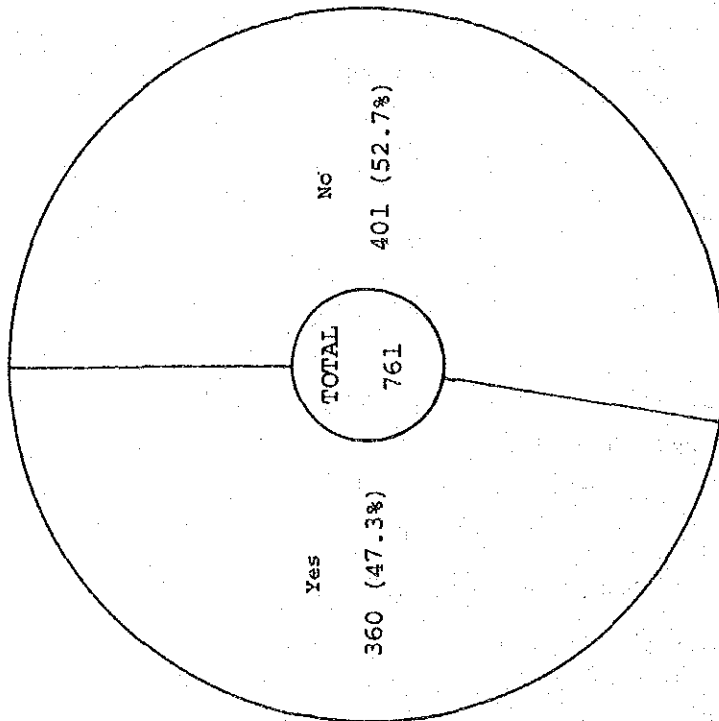
6) Willingness to Pay for Water per Month (Table-5.3, Fig-5.4 (5))

Of those repliers willing-to-be-connected people, nearly a half, i.e., 255 out of 338, answered 50 baht or less as a willing-to-pay amount.

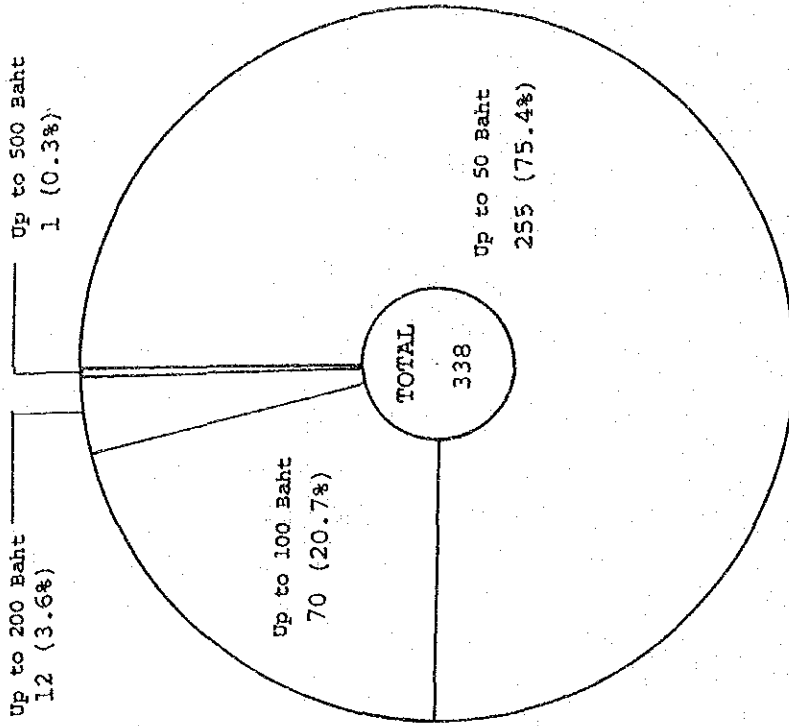
7) Average Monthly Household Income (Table-5.3, Fig-5.4 (6))

765 other sources-than-Municipal-System users and 88 wholly-or-partly-Municipal-System users were questioned and the result is shown for each separately.

WILLINGNESS TO BE CONNECTED

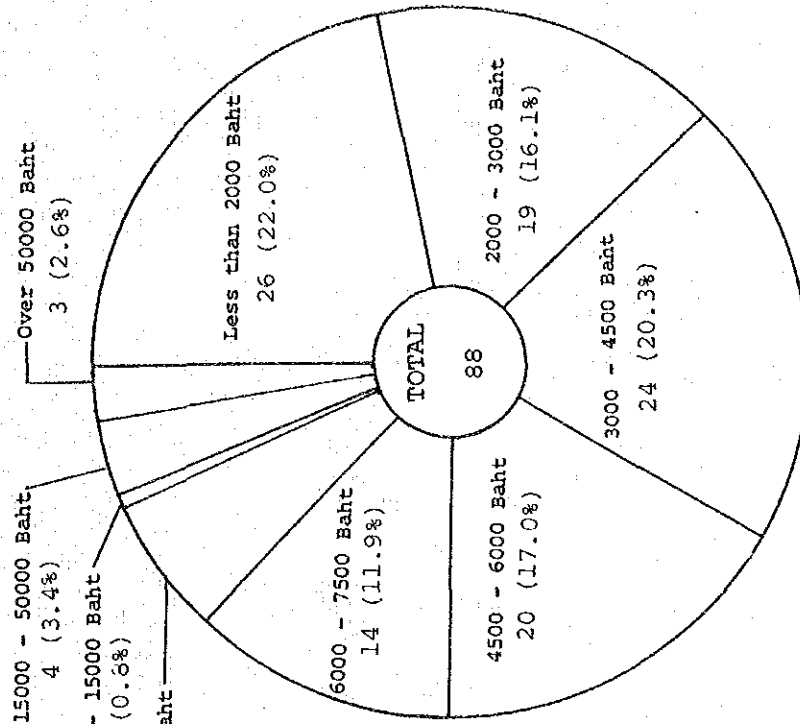


WILLINGNESS TO PAY FOR WATER PER MONTH

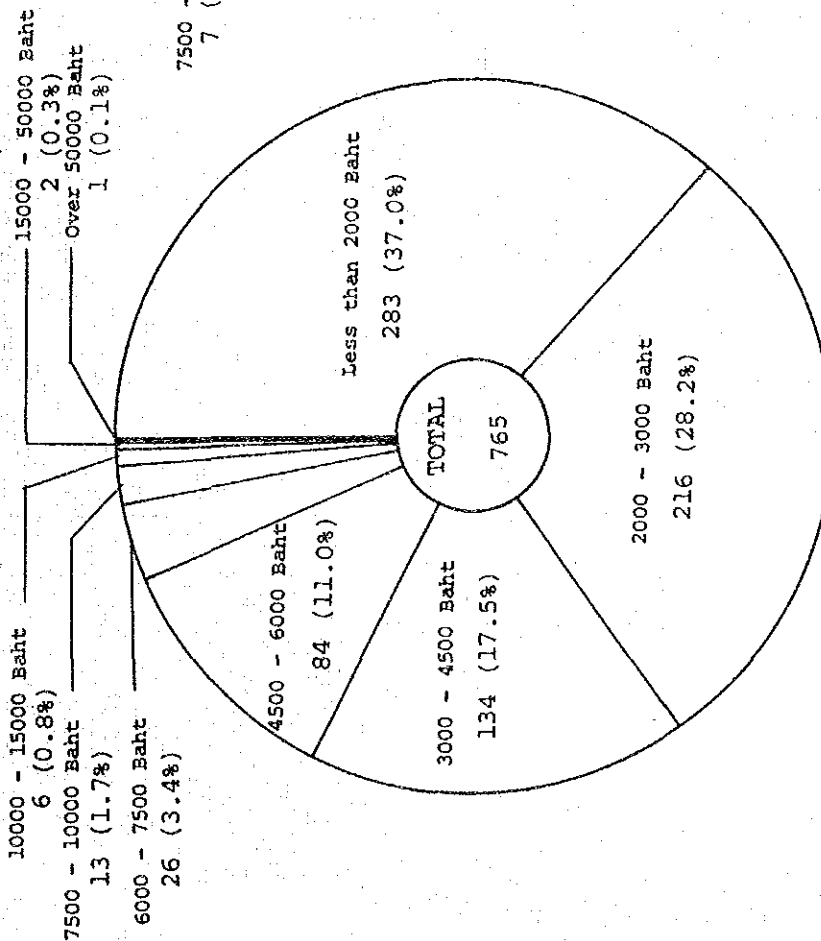


**FIGURE** QUESTIONNAIRE SURVEY RESULTS ( 5 )  
5.4 (5) ( SANITARY DISTRICTS )

AVERAGE MONTHLY HOUSEHOLD INCOME  
(MUNICIPAL SYSTEM PLUS OTHER SOURCES)



AVERAGE MONTHLY HOUSEHOLD INCOME  
(SOURCES OTHER THAN MUNICIPAL SYSTEM)



FIGURE

QUESTIONNAIRE SURVEY RESULTS ( 6 )

5.4(6)

( SANITARY DISTRICTS )

JAPAN INTERNATIONAL COOPERATION AGENCY

The monthly household income of 82.7 % of those not receiving PWA services was less than 4,500 Baht while the percentage of those receiving PWA services whose monthly household income was less than 4,500 Baht amounted only to 58.4 %. This indicates that the average household income level of those receiving PWA services was higher than that of those not receiving PWA services.

**APPENDIX 6**

**DESIGN CRITERIA**



APPENDIX 6 DESIGN CRITERIA

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6.7	Drinking Water Standard .....	A6 - 7





## APPENDIX 6 DESIGN CRITERIA

The design criteria mentioned herein are applied to the preliminary design of the present project. They were concluded after studying the PWA design criteria and the concepts widely accepted in waterworks field and discussing them with PWA.

## 6.1 Peak Factors

The factors have not been established as criteria and the table below shows the peak factors planned for this project.

<u>City/Town</u>	<u>Peak Factor by Day</u> <u>(Max Day/Ave Day)</u>	<u>Peak Factor by Hour</u> <u>(Max Hour/Ave Hour*)</u>
Chiangmai	1.25	1.30
Ubon, Warin	1.30	1.40
Pattaya	1.30	1.20
Suphanburi	1.35	1.40
Five S.D.s in Chiangmai	1.35	1.50

\* Ave Hour = 1/24 Max Day

The peak factor by day was estimated for each of the domestic and tourism demands separately and the listed figure is the average. Using the peak factors, the average day demand, maximum day demand and maximum hour demand are calculated.

These demands are used in making calculation mostly of:

- Average Day Demand: financial and economic study
- Maximum Day Demand: production facility design
- Maximum Hour Demand: distribution facility design.

## 6.2 Water Loss in Production

Water loss is counted in the design of production facilities. They are assumed to be:

Treatment Plant : 8 % of production capacity including filter washing and other in-plant consumptions  
 Intake, Transmission : 2 % of production capacity

## 6.3 Concrete Structure

Concrete structures for production and distribution must be designed following the practiced design method prevailing in Thailand.

## 6.4 Pipeline

Pipelines must be designed based on consideration of hydraulic conditions, geologic conditions, pipe and joint material and others.

## 6.5 Treatment Plant Facilities

### 1) Flash Mixing

Type of mixing : hydraulic  
 Intensity, G (1/s) : 500 - 1,000  
 Time of mixing, t (s) : 1 - 3

## 2) Flocculation

Type of mixing : hydraulic  
 No. of stages : more than 3  
 Intensity, G (1/s) : 10 - 70, tapered  
 Detention time (min) : 20 - 40  
 Others : minimum of 2 basins, easy removal of scum and sludge

## 3) Sedimentation

Type : rectangular basin, one direction horizontal flow  
 Hydraulic loading : 1 - 2 m<sup>3</sup>/m<sup>2</sup>/hr  
 Flow velocity (m/min) : 0.3 - 1  
 Detention time (hr) : 1.5 - 3  
 Water depth (m) : more than 3 plus sludge deposit thickness estimated on the interval of cleaning  
 Weir loading (m<sup>3</sup>/m.d) : less than 300 (less than 15 gpm/ft)  
 Length/width ratio : more than 5, dummy wall considered  
 Sludge collection : manual

## 4) Filtration

Type : gravity rapid sand filter  
 Filt. rate (m/hr) : less than 7, for declining rate filtration

Filter Bed

Type : single media  
 Minimum no. of filter : 4  
 Minimum size of filter : 3 m x 4 m  
 Effective size of sand : 0.55 - 0.75 mm  
 Uniformity coefficient : 1.7  
 Minimum depth : 750 mm

Underdrains

Type : pipe lateral  
 No. of gravel layers : minimum 4  
 Thickness of each : more than 100 mm

Surface wash

Type : fixed nozzle  
 Rate (m/min) : 0.12 - 0.17  
 Head (kg/cm<sup>2</sup>) : more than 1.0  
 Jet velocity (m/s) : 6 - 7

Backwash

Rate (m/min) : more than 0.6

## 5) Clear Water Reservoir in Treatment Plant

Function : storage for in-plant consumption including backwashing  
 Type : elevated and/or ground level  
 For backwash : minimum storage for 2 filters consecutive backwashing

## 6) Chemical Feeding

Alum

No. of tank : more than 2  
 Feeder : metering pump or manual control with flow meter, recycle bypass, corrosion-resistant pump

Lime

- Objective : pH control for coagulation and/or pipe protection against corrosion
- No. of tank : more than 2

At least 1 stand-by feeder is to be provided for alum and lime.  
Gauges at outside of the tanks are preferable.

7) Chlorination

- Chemicals form : chlorine gas and/or bleaching powder
- Minimum storage : 1 months
- No. of standby chlorinator: more than 1
- Scale : periodical recording of consumptions to be practiced

8) Instrumentation

- Flow to be measured : raw water and treated water of treatment plant, chemicals, chlorine
- Level to be measured : clear water reservoir, chemical tank
- Weight to be measured : chlorine

In selecting the measuring devices, durability, robustness, easiness of operation and maintenance (changing parts, repair) are to be given priority to, for instance, high accuracy.

6.6 Distribution Facilities

1) Service Pressure

The minimum service pressure under the maximum hour flow is set at 1.0 kg/cm<sup>2</sup> for general application, except for rural area where 0.7 - 0.8 kg/cm<sup>2</sup> be tolerated.

2) Storage of Distribution Reservoir

When sufficient data regarding the characteristics of fluctuation area collected in future, the storage problems are to be studied.

Increasing the existing storage capacity is not considered in the rehabilitation/modification works, but in the expansion works, construction of a reservoir retaining 6 hour production volume for the expanded capacity is planned.

3) Pipe Material

In selecting pipe material, conditions such as strength against internal and external loads, importance of the pipeline, suitability to ground conditions, workability in existing conditions and influence on water quality must be considered.

Asbestos cement pipes, corrosion coated when necessary, are to be used preferably for economic reasons. For cases requiring pipe strength such as road crossing works and the like, ductile cast iron pipes are to be employed.

4) Pipe Size

Pipe size is selected based on the flow requirements. In this preliminary design, the maximum hour flow is employed for the pipe size selection.

5) Valves

The location of stop valves is selected upon consideration of convenience in operation and maintenance, such as:

- control of flow to equalize distribution or reduce excessive pressure
- isolation of a section of distribution area
- isolation of in-line facilities like railway, riverbed crossing and pipe-bridge

PWA criteria of 1 km minimum distance is observed.

The location of drain valves is selected upon consideration such as:

- emptying a pipeline in emergency like bursting
- draining wastewater in periodical cleaning works

Air valves are to be located at all the peaks in a pipeline's profile.

#### 6) Fire Hydrant

The location of fire hydrants is selected upon consideration such as:

- existence of nearby natural and/or man-made water like streams, canals swamps, etc.
- characteristics of the area to be protected, for instance, existence of factories handling inflammable matters, congested wooden housings, etc.

#### 7) Anchor Block

To prevent displacement or slip-off of bends and tees, anchor blocks are used where necessary.

#### 6.7 Drinking Water Standard

Tables-6.1 and 6.2 show the PWA Drinking Water Standard of Surface Water Source and of Groundwater respectively.

The treatment facilities, preliminary designed on the basis of the design criteria in 6.5 for processing raw water of two surface water sources of Pattaya, are required to produce treated water conforming to the standard.

Table-6.1 DRINKING WATER STANDARD OF SURFACE WATER SOURCE

<u>PHYSICAL PROPERTIES</u>	<u>MAXIMUM ACCEPTABLE CONCENTRATION (mg/l)</u>	<u>MAXIMUM ALLOWABLE* CONCENTRATION (mg/l)</u>
Color (Platinum Cobalt Unit)	5	15
Taste	unobjectionable	unobjectionable
Odour	unobjectionable	unobjectionable
Turbidity (Silica Scale Unit)	5	20
pH	6.5 to 8.5	not over 9.2
<u>CHEMICAL PROPERTIES</u>		
Total Solids	500	1,500
Total Hardness as CaCO <sub>3</sub>	300	500 (WHO 1971)
Iron (Fe)	0.5	1.0
Manganese (Mn)	0.3	0.5
Iron an Manganese	0.5	1.0
Copper (Cu)	1.0	1.5
Zinc (Zn)	5.0	15
Calcium (Ca)	75**	200
Magnesium (Mg)	50	150
Sulphate (SO <sub>4</sub> )	200	250***
Chloride (Cl)	250	600
Fluoride (F)	0.7	1.0
Nitrate (NO <sub>3</sub> )	45	45
Alkyl Benzyl Sulfonates (ABS)	0.5	1.0
Phenolic Substances as Phenol	0.001	0.002
<u>TOXIC SUBSTANCES</u>		
Mercury (Hg)	0.001	
Lead (Pb)	0.05	
Arsenic (As)	0.05	
Selenium (Se)	0.01	
Chromium Hexavalent (Cr)	0.05	
Cyanide (CN)	0.2	
Barium (Ba)	1.0	
Cadmium (Cd)	0.01	



Table-6.1 DRINKING WATER STANDARD OF SURFACE WATER SOURCE (cont'ed)

<u>BACTERIOLOGICAL PROPERTIES</u>	<u>MAXIMUM ACCEPTABLE CONCENTRATION</u>
Standard Plate Count (N/ml)	500
Most Probable Number	
Coliform Organisms (N/100 ml)	less than 2.2
Escherichia Coli	None

## Notes:

\* The maximum allowable concentration is allowable for waterworks and well used for human consumption temporarily only and the water property is between the maximum acceptable and maximum allowable and will not be entitled to use the standardized trademark.

\*\* If the Calcium (Ca) is higher than the limit and the Magnesium (Mg) is lower, the standard shall be considered as Ca and Mg in terms of total hardness. If the total hardness calculation in terms of  $\text{CaCO}_3$  is lower than 300 mg/l, the water is according to the standard classification of water hardness in the following:

0 - 75 mg/l = Soft water  
 75 - 150 mg/l = Mean hard water  
 150 - 300 mg/l = Hard water  
 up 300 mg/l = Very hard water

\*\*\* If the Sulfate value reached 250 mg/l, the Magnesium (Mg) shall not exceed 30 mg/l.

Table-6.2 Drinking Water Standard of PWA (Groundwater)

<u>PHYSICAL PROPERTIES</u>	<u>MAXIMUM ACCEPTABLE CONCENTRATION (mg/l)</u>	<u>MAXIMUM ALLOWABLE CONCENTRATION (mg/l)</u>
Color (Platinum Cobalt Unit)	5	50
Turbidity (Silica Scale Unit)	5	20
pH	7.0 to 8.5	6.5 to 9.2
<u>CHEMICAL PROPERTIES</u>		
Iron (Fe)	0.5	1.0
Manganese (Mn)	0.3	0.5
Copper (Cu)	1.0	1.5
Zinc (Zn)	5.0	15
Sulphate (SO <sub>4</sub> )	200	250
Chloride (Cl)	200	600
Fluoride (F)	1.0	1.5
Nitrate (NO <sub>3</sub> )	45	45
Total Hardness as CaCO <sub>3</sub>	300	500
Non Carbonate Hardness as CaCO <sub>3</sub>	200	250
Total Solids	750	1,500
<u>TOXIC SUBSTANCES</u>		
Arsenic (As)	N.D.	0.05
Cyanide (CN)	N.D.	0.2
Lead (Pb)	N.D.	0.05
Mercury (Mg)	N.D.	0.001
Codmium (Cd)	N.D.	0.01
Selenium (Se)	N.D.	0.01
(N.D. : Not to be detected)		
<u>BACTERIOLOGICAL PROPERTIES</u>		
Standard Plate Count (N/ml)	500	
Most Probable Number (Coliform Organism/100 ml)	less than 2.2	
Escherichia Coli	None	

APPENDIX 7

COMPARISON OF UNIT PRICE AND COST  
OF  
WATER BETWEEN PWA AND PRIVATE FACILITIES



APPENDIX 7      COMPARISON OF UNIT PRICE AND COST OF WATER BETWEEN PWA AND  
PRIVATE FACILITIES

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APPENDIX 7    COMPARISON OF UNIT PRICE AND COST OF WATER BETWEEN PWA AND  
PRIVATE FACILITIES

7.1    Basic Assumptions

1)    Water Volume

This study of comparison was made of comparatively large sized consumers, whose monthly consumption volumes range at 50, 100, 200, 300, and 500 cu m per day.

2)    PWA Price

The PWA price of water is assumed to include water tariffs, service charges and connection fees. Connection fees which are chargeable for the connection work prepared by PWA at the initiation of PWA service are assumed to be distributed to the PWA price of water for 20 years by equal monthly lot.

3)    Cost of Water Produced by Private Facilities

Cost is assumed to include operation and maintenance cost, together with capital investment for construction of facilities. Investment cost is distributed for 240 months in terms of monthly depreciation.

## 7.2 Unit Cost of Water by Private Facilities

Raw water assumed to be lifted by a submersible pump, disinfected by dosed bleaching powder and, lifted to an elevated tank with the remaining pressure.

The details of the assumed facilities are shown in Table-7.1.

- |                       |  |
|-----------------------|--|
| a. Water Source       | : deep well, 80 meter depth  |
| b. Location of Well   | : in Chiangmai Municipality  |
| c. Raw Water Quality  | : 5 mg/l or less iron, 0.5 mg/l or less manganese  |
|                       | pH - approximate 7.5<br>(medium values of varying data collected from existing wells)                                      |
| d. Treatment Process  | : Oxidation of iron and manganese by bleaching powder, filtration, disinfection by chlorine, of the dosed bleaching powder |
| e. Treatment Capacity | : 50, 100, 300, 500 cu m/d   |

### Construction Cost

Submersible pumps are assumed to be imported, but their installation and construction of wells, pipeworks and erection of elevated tanks are assumed to be made locally.

### O/M costs

- a person is assumed to engage in the operation and maintenance of the system for 1.5 hr per day, doing other works in the remaining hours.
- repair cost is estimated at 0.5 % of the construction costs.
- electricity cost is estimated with 24 hrs' run throughout the year.



Table-7.1 PRIVATE WELL FACILITIES

Item	No.	50 cu m/d capacity Description	100 cu m/d capacity Description	300 cu m/d capacity Description	500 cu m/d capacity Description
1) Deep Well dia. x depth	1	125 mm x 80 m	125 mm x 80 m	150 mm x 80 m	150 mm x 80m
2) Submersible Pump dia. x capacity x head x motor rating	1	40 mm x 0.04 cu m/min 25 m x 1.1 KW	40 mm x 0.07 cu m/min 25 m x 1.1 KW	50 mm x 0.21 cu m/min 25 m x 2.2 KW	65 mm x 0.35 cu m/min 25 m x 3.7 KW
3) Pump House width x length	1	brick, 4 m x 4 m	brick 4 m x 4 m	brick, 4 m x 4 m	brick, 4 m x 4 m
4) Treatment Capacity	1	50 cu m/d	100 cu m/d	300 cu m/d	500 cu m/d
5) Elevated Tank Capacity	1	5 cu m	10 cu m	30 cu m	50 cu m
6) Pipeworks	L.S.	1 set, incl. pipes, valves, fittings	1 set, incl. pipes, valves, fittings	1 set, incl. pipes, valves, fittings	1 set, incl. pipes, valves, fittings
7) Miscellaneous Works	L.S.				

Note:

L.S. : lump sum

Treatment system incl. filter, bleaching powder feeding, backwash pump

- 10 mg/l dosage of bleaching powder containing 30 % effective chlorine is assumed to be dosed constantly.

### Unit Cost of Water

The construction costs are distributed in equal monthly depreciation allowances for 20 years, and with the depreciation allowances and monthly O/M costs, unit (cubic meter) water cost is estimated as shown in Table-7.2.

Table-7.2 UNIT COSTS OF WATER, PRIVATE WELL

<u>Item</u>	<u>Production Capacity (m<sup>3</sup>/d)</u>			
	<u>50</u>	<u>100</u>	<u>300</u>	<u>500</u>
1. Construction Cost				
- Amount of Investment (x 1,000 Baht)	2,922	3,066	3,412	3,777
- Monthly Depreciation (20 years, Baht/month)	12,180	12,780	14,220	15,740
2. O/M Cost (Baht/month)	4,670	5,420	9,920	14,170
3. Monthly Cost (Baht/month)	16,850	18,200	24,140	29,910
4. Unit Cost of Water (Baht/m <sup>3</sup> )	11.23	6.07	2.68	1.99

### 7.3 Unit Price of Water by PWA

As the study is made on consumption volumes of 50 cu m per day or more, the water tariff is assumed to be charged at a flat rate of 8.5 Baht/cu m, together with service charges and connection fees as described in Table-7.3 below.

Table-7.3 UNIT PRICE OF WATER, PWA

<u>Item</u>	<u>Water Consumption (m<sup>3</sup>/d)</u>			
	<u>50</u>	<u>100</u>	<u>300</u>	<u>500</u>
1. Size of connection Pipe (inches)	2	3	4	6
2. Water Price				
- Service Charge (Baht/month)	100	160	200	200
- Connection Fees in terms of monthly lot (20 years)*	80	130	250	250
- Monthly Price (Baht/month)	12,750	25,500	76,500	127,500
- Total Monthly Price (Baht/month)	12,930	25,790	76,950	127,900
3. Unit Price of Water (Baht/m <sup>3</sup> )	8.62	8.60	8.55	8.52

Note: \* Based upon the assumption that connection is set at 30 m from the main pipe, i.e., 2 x Basic Fee.

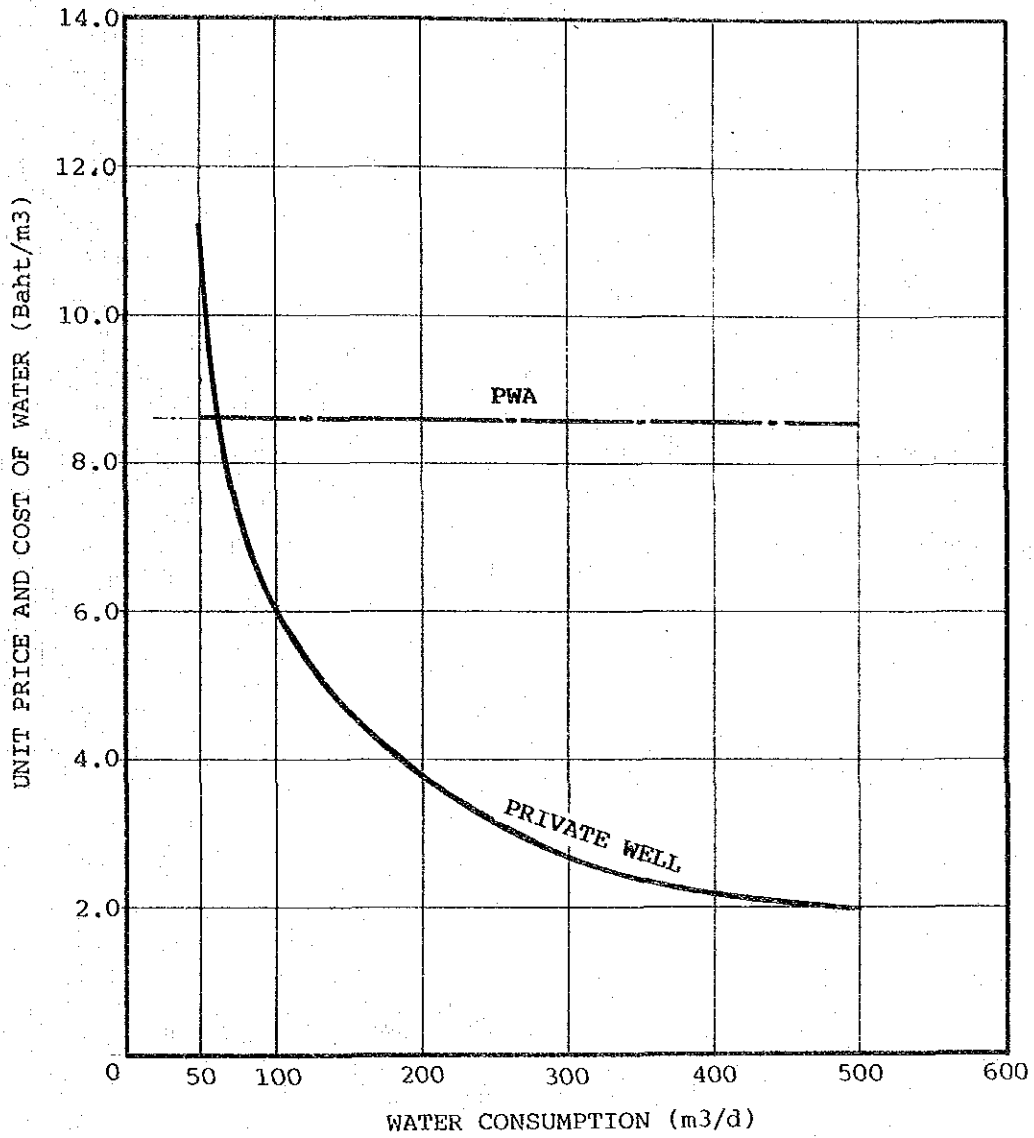
#### 7.4 Remarks

The following can be induced from the study results as revealed in Fig-7.1.

1. The break-even point where the unit cost of water produced by private facilities and the unit price of water by PWA may be found at a consumption volume between 50 m<sup>3</sup>/day and 100 m<sup>3</sup>/day, and very near to 50 m<sup>3</sup>/day.
2. The unit cost of water by private facilities decreases as the consumption volume increases, i.e., so low as 1.99 Baht/m<sup>3</sup> at 500 cu m per day.
3. Because of no exact data available on the ratio of successful drilling in Chiangmai, no consideration is given to such ratio. If the ratio

is assumed to be 50 %, the unit cost of water per cu m in case of 100 m<sup>3</sup>/day consumption will be 10.33 Baht\* which exceeds PWA's unit price of water.

Note:  $[\text{monthly depreciation allowances (12,780 Baht} \times 2) + \text{monthly O/M cost (5,420 Baht)}] / \text{consumption volume (100 m}^3 \times 30 \text{ days)} = 10.33 \text{ Baht/m}^3$



COMPARISON OF UNIT PRICE AND COST

WATER CONSUMPTION (m <sup>3</sup> /d)	PWA (Baht/m <sup>3</sup> )	PRIVATE WELL (Baht/m <sup>3</sup> )
50	8.62	11.23
100	8.60	6.07
300	8.55	2.68
500	8.52	1.99

<b>FIGURE</b>	COMPARISON OF UNIT PRICE AND COST
7.1	
JAPAN INTERNATIONAL COOPERATION AGENCY	



**APPENDIX 8**

**PRELIMINARY DESIGN**





APPENDIX 8 PRELIMINARY DESIGN

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## Appendix 8 PRELIMINARY DESIGN

## 8.1 Rehabilitation and Modification Works

The objectives for the rehabilitation and modification works, which are 1) to update the present deteriorated equipment and obsolete pipelines and 2) to uprate the present production of the Paton Treatment Plant, by some improvements for covering insufficient supply till completion of the expansion works.

The possible increase of production capacity is studied on the Paton Treatment Plant. Each of the facilities in Paton system is examined for its capacity whether it meets with the proposed increase as follows:

- Present capacity : 16,000 cu m/d
- Proposed incremental : 4,000 cu m/d  
(25 % to the present capacity)
- Proposed production : 20,000 cu m/d
- Proposed treatment capacity : 21,600 cu m/d  
(the proposed production plus 8 % treatment loss)

## 8.1.1 Intake pump and Raw Water Transmission Pipeline for Paton System

## 1) Capacity

The existing intake pumps are as follows:

- Motor drive, 12.2 cu m/min (17,600 cu m/day) x 47 m H x 2 Nos.  
(1 standby)
- Motor drive, 5.4 cu m/min ( 7,800 cu m/day) x 48 m H x 1 No.

Each of the pump units is found sufficiently operable, and the combined capacity of the 12.2 and 5.4 cu m/min pumps (25,400 cu m/d) nearly equals the Wang Sing Kam and Paton treatment capacity of 24,000 cu m/d including water losses.

Additional two pumps as described afterwards, will be installed for

increase capacity 4,000 cu m/d of the Paton plant.

500 mm and 300 mm diameter raw water transmission mains of 3,100 m and 4,200 m length respectively are operated. For transmitting water to the two treatment plants, these two mains are adequate hydraulically and structurally. Therefore the raw water transmission mains are considered to meet the proposed treatment capacity up to 1991.

## 2) Necessary Works

Two additional raw water pumps and appurtenances will be installed in the existing pump station of Ban Tho Intake:

- Q 3.1 cu m/min x H 46 m x 2 nos.

The flow meters and recorders of 500 mm and 300 mm raw water transmission mains, malfunctioning and unable to record the intake flow, should be replaced by new instruments of the differential pressure type.

## 8.1.2 Treatment Facilities

## 1) Increase of production capacity of the Paton Treatment Plant

Item	Original Design	Proposed Modification	Design Criteria (Appendix 6)
Production Capacity (cu m/d)	16,000	20,000 (25 % increase)	- -
Treatment Capacity (including loss, cu m/d)	17,300	22,000	- -
Flocculation Basins			
Detention Time (min)	37	27	20 - 40
Sedimentation Basins			
Detention Time (hr),	3.3	2.4	1.5 - 3
Flow Velocity (m/min)	0.19	0.24	0.3 - 1
Filters			
Filtration Rate (m/hr) (of 6 beds, one standby included)	4.5	5.7	7

The parameters of the proposed production are consistent with the design criteria of the present study, so it is concluded that the production capacity of the Paton Treatment Plant can be increased technically to 20,000 cu m/d, within reasonable investment of capital.

## 2) Necessary Works

## a) Wang Sing Kam Treatment Plant

## (1) Replacement and installation of chemical feeding equipment

The outdated alum feeding equipment should be replaced and a lime

feeding system will be installed to control pH for more adequate coagulation.

- Alum solution tank, feeding pump with piping, valves and flow meter: 2 units
- Lime solution tank, feeding pump with piping, valves and flow meter: 2 units

(2) Replacement of level gauge and water meter

The defective float type water level gauges (field readout type) will be replaced, for measuring level of the clear water reservoir and the elevated tank. The malfunctioning raw and treated water flow meters and recorders will be replaced by new ones for determination of accurate chemical dosage and recording daily production of water.

(3) Provision of chlorine gas container scale

A set of chlorine gas container scale will be provided for precise timing of replacement of gas container to secure continuous disinfection as well as reading consumption.

(4) Replacement or washing of filter media and repair of underdrain

Filter sand of 72 sq m or 6 filter beds in total should be replaced or thoroughly washed to undertake sufficient filtration. In addition, the underdrain of all filters will be repaired.

(5) Purchase of filter sand washer

A movable filter sand washer is proposed for purchase, and washing of filter sand should be practiced to provide clean sand for make-up and/or replacement.

(6) Installation of distribution pump

The existing inrepairable pump should be abandoned and two pumps, as specified below, including one standby will be installed instead.

- Q 7.2 cu m/min x H 20 m x 1 no.
- Q 3.6 cu m/min x H 20 m x 1 no.

b) Umong Treatment Plant

(1) Replacement and installation of chemical feeding equipment

- Alum feeding pump with piping, valves and flow meter: 2 units
- Lime solution tank, feeding pump with piping, valves and flow meter: 2 units

(2) Replacement of level gauge and water meter

- Float type water level gauge for the clear water reservoir: 2 sets
- Raw water flow meter and recorder of 600 mm diameter: 1 unit

(3) Provision of chlorine gas container scale: 1 unit

(4) Replacement of broken drain pipes of sedimentation basin

- 100 mm diameter: 20 pipes

(5) Replacement or washing of filter media and repair of underdrain

- 8 filter beds: 390 sq m

## c) Paton Treatment Plant

## (1) Replacement of chemical feeding equipment

For increase of production capacity, additional chemical feeding equipment should be installed. Chemical storage tanks will be also constructed.

- Alum feeding pump with piping, valves and flowmeter: 2 units
- Lime feeding pump with piping, valves and flowmeter: 2 units
- Alum solution tank: 1
- Lime solution tank: 2

## (2) Replacement of flow meter

- A flow meter and recorder of 500 mm diameter raw water transmission pipe: 1 set
- A flow meter and recorder of 600 mm diameter distribution main: 1 set

## (3) Installation of hanging nets, a device for improving flocs settlement, in the sedimentation basin

- Width 3.5 m x Depth 3.0 m x 10 nets

## (4) Replacement or washing of filter media and repair of underdrain

- 6 filter beds: 200 sq m

## (5) Reinstallation of head stocks for filter washing valves

- Backwash valve: 6 sets
- Surface wash valve: 6 sets
- Drain valve: 6 sets



## (6) Installation of distribution pump

Q 13.9 cu m/min x H 30 m x 2 nos.

## d) Mae Rim and San Kamphaeng Treatment Plants

(1) Provision of a chlorine gas container scale for both plants

## 8.1.3 Distribution Pipeline for Chiangmai

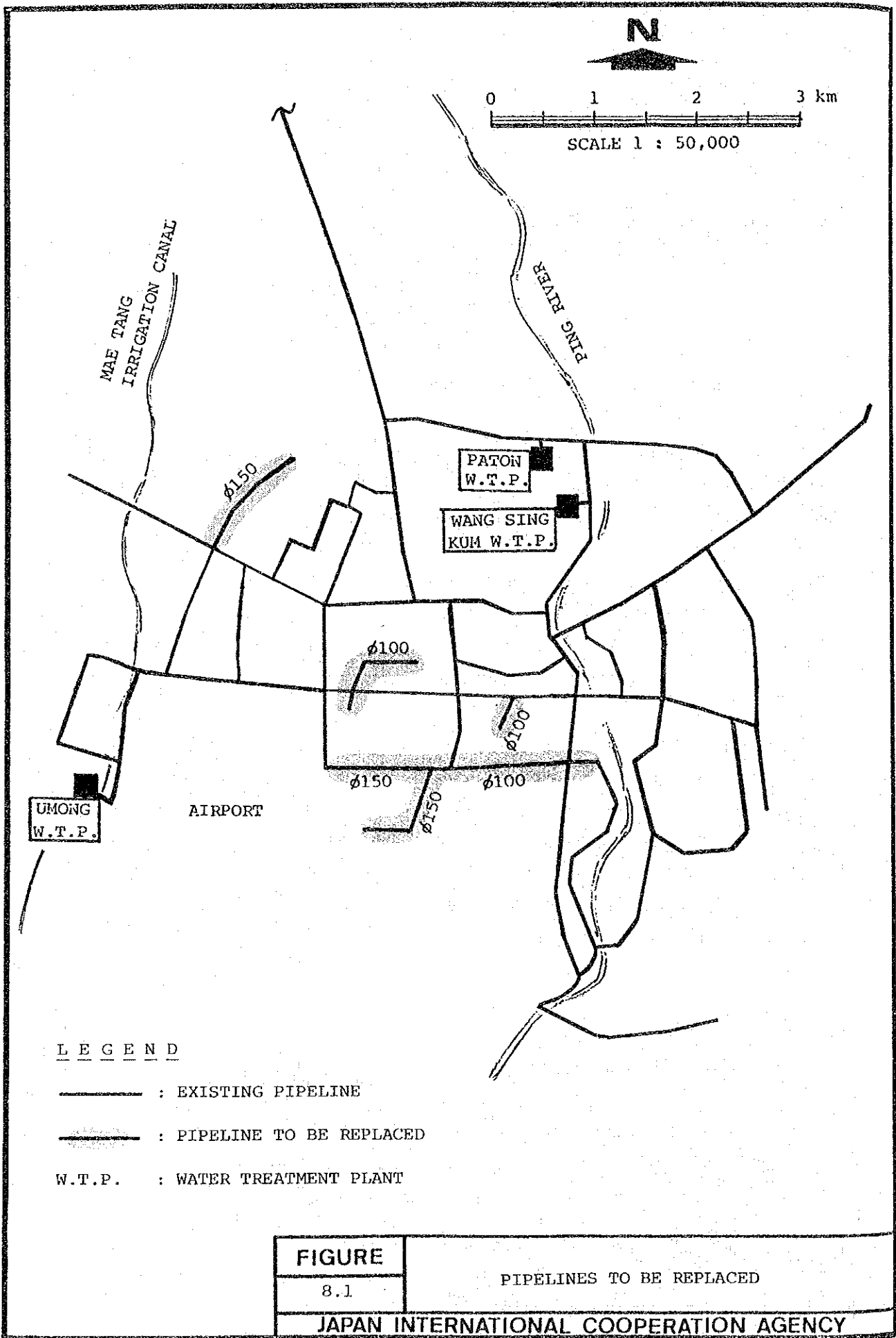
Immediate replacement is proposed for obsolete and defective pipes. The waterworks also requested the relocation of those pipes installed under rain sewers or in driveways where traffic is heavy.

The locations are shown in and Table-8.1 and Fig-8.1.

Table-8.1 LIST OF PIPELINES TO BE  
INSTALLED OR REPLACED

PIPE	LENGTH
Dia. 150 mm	2,900 LM
Dia. 100 mm	1,850 LM

(NOTE) LM : Linear Meters



LEGEND

- : EXISTING PIPELINE
- : PIPELINE TO BE REPLACED
- W.T.P. : WATER TREATMENT PLANT

<b>FIGURE</b>	PIPELINES TO BE REPLACED
8.1	
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## 8.2 Expansion Works for Chiangmai

### 8.2.1 Condition of the Preliminary Design

The design flow of each facility to be constructed in the Stage I Expansion Works is as follows:

- (1) Ban Tho Intake and Raw Water Transmission Pipeline  
(Max. Day Demand + Treatment Loss + Pipeline Loss): 22,000 cu m/d
- (2) Paton Treatment Plant Facilities  
(Max. Day Demand + Treatment Loss) : 21,600 cu m/d
- (3) Distribution Facilities (Peak Hour)
  - Paton distribution pump station : 52,000 cu m/d
  - Umong distribution pump station : 37,300 cu m/d
  - Wang Sing Kam distribution pump station : 10,300 cu m/d

### 8.2.2 Intake and Raw Water Transmission Pipeline

Intake barrage is planned to be constructed across the Ping River to maintain the level of taking water, so that those influences inevitably resulting from barrage construction may be minimized.

Grit chambers are provided to remove grit and sand flowing in with surface water which is taken by means of intake gate, screen and sludge pumps.

- 1) Intake
  - Barrage : Gravity type barrage (HWL 301.5 m above sea level), with riverside protection, flush gates, access bridge and subsidiary works
  - Grit Chamber : 10 min. detention, 2 chambers, with traveling submersible pump
  - Appurtenances : intake gates, screen

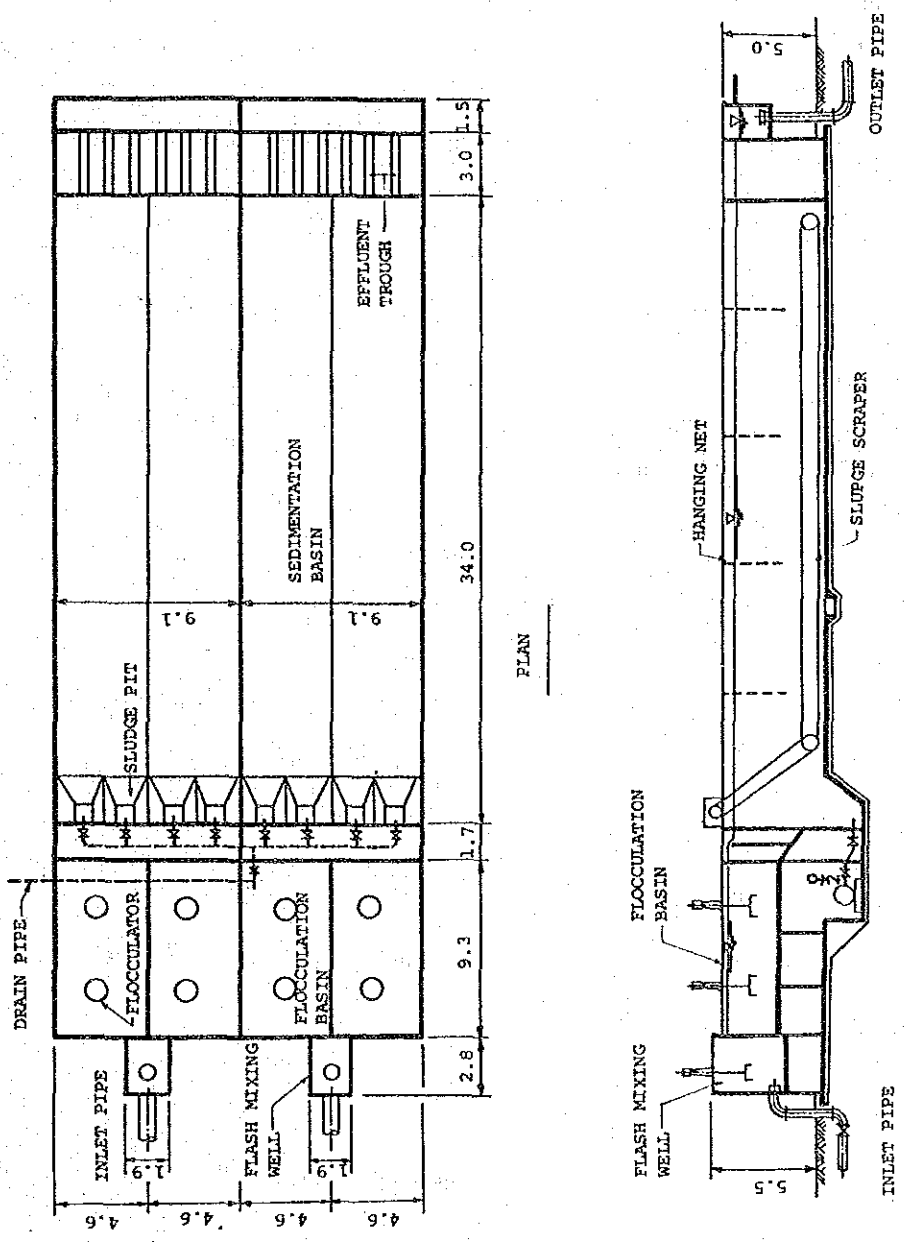
- 2) Pump Station
  - Raw Water Pump : Q 15.3 m<sup>3</sup>/min x H 47 m x 2 nos.
  - Appurtenances : valves, pipes and electric equipment
  
- 3) Pipeline
  - From To : Ban Tho Intake to Receiving Well of Paton Treatment Plant
  - Dia. and Length : 500 mm and 3,100 m
  - Equipped with : flow meter (described before),  
branch for Stage II expansion

### 8.2.3 Paton Treatment Plant

Water quality of the Ping River is acceptable as the raw water to be treated by a series of treatment processes of coagulation, flocculation, sedimentation, rapid sand filtration and post-chlorination as planned in the Stage I Expansion Works.

The capacity, dimensions and features of the proposed facilities are described below:

- 1) Flash Mixing Well (Fig-8.2)
  - vertical type flash mixer
  - W 1.9 m x L 1.9 m x D 2.1 m, 2 wells,
  - Detention Time : 1.0 min
  
- 2) Flocculation Basin (Fig-8.2)
  - vertical type flocculator
  - Volume : 100 cu m/basin, Detention Time : 27 min, 4 basins,
  
- 3) Sedimentation Basin (Fig-8.2)
  - rectangular, one direction horizontal flow,
  - Volume : 1,100 cu m/basin, 2 basins, W 9.1 m x L 34.0 m x D 3.5 m,
  - Detention Time : 2.4 hrs, hydraulic loading : 1.5 m<sup>3</sup>/m<sup>2</sup>/h,
  - flow velocity : 0.24 m/min,
  - Desludge method : Sludge scraper



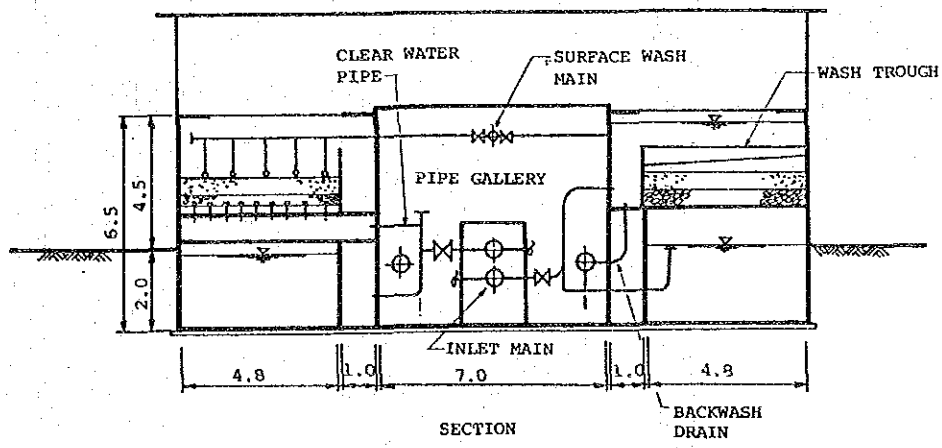
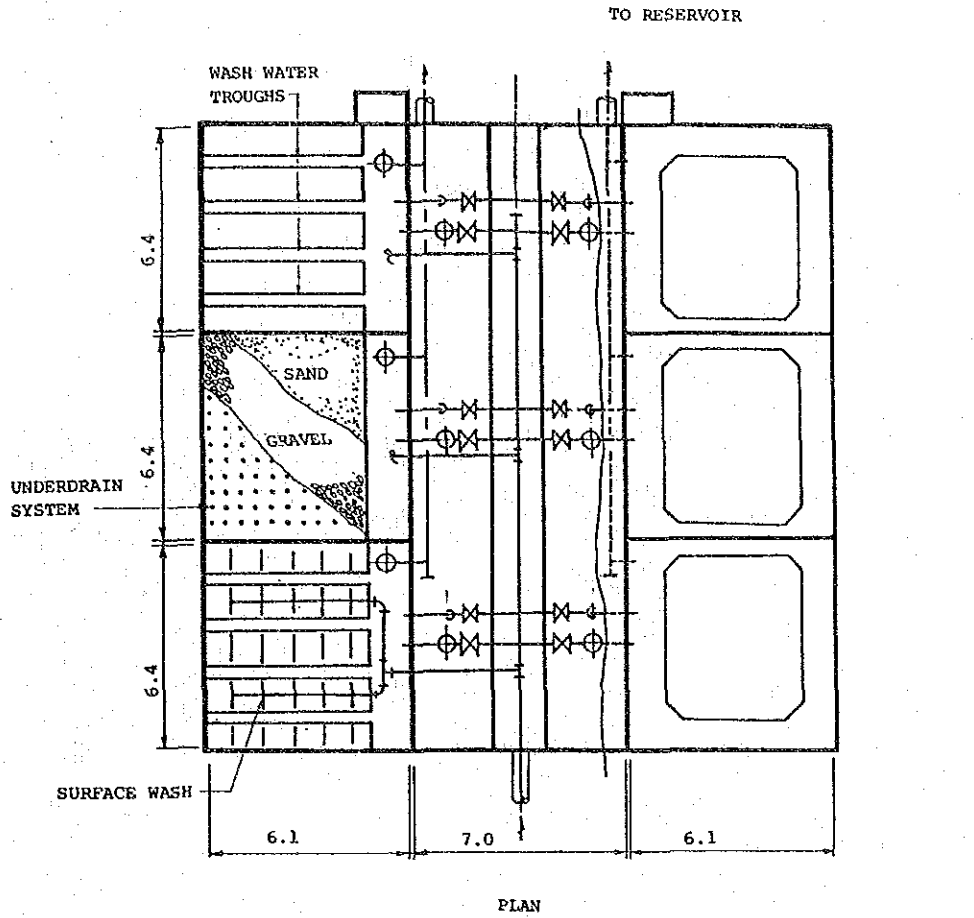
<b>FIGURE</b>	FLASH MIXING, FLOCCULATION AND SEDIMENTATION BASIN
	8.2
<b>JAPAN INTERNATIONAL COOPERATION AGENCY</b>	

- 4) Rapid Sand Filter (fig-8.3)  
constant rate filtration,  
filtration rate : 137 cu m/sq m/d in average,  
6 filter beds including 1 stand-by, 32 sq m/bed,  
backwashing together with surface washing
  
- 5) Clear Water Reservoir (fig-8.4)  
Function of clear water reservoir is to regulate the fluctuations  
occurring between the quantity of filtrate and that of delivery as  
well as at the time of power suspension or sudden changes in  
supply.  
Volume : 2,500 cu m/reservoir, 2 reservoirs
  
- 6) Chemical Feeding Equipment
  - Alum  
solution tanks with mixers, feeding pumps, elevated header  
tanks, and appurtenances
  - Lime  
hopper, solution tanks with mixers, feeding pumps, header tank,  
saturation tanks and appurtenances
  - Post Chlorination  
container scale, evaporator, chlorinator and appurtenances
  
- 7) Instrumentation
  - flow meter and controller
  - flow and level indicator and recorder

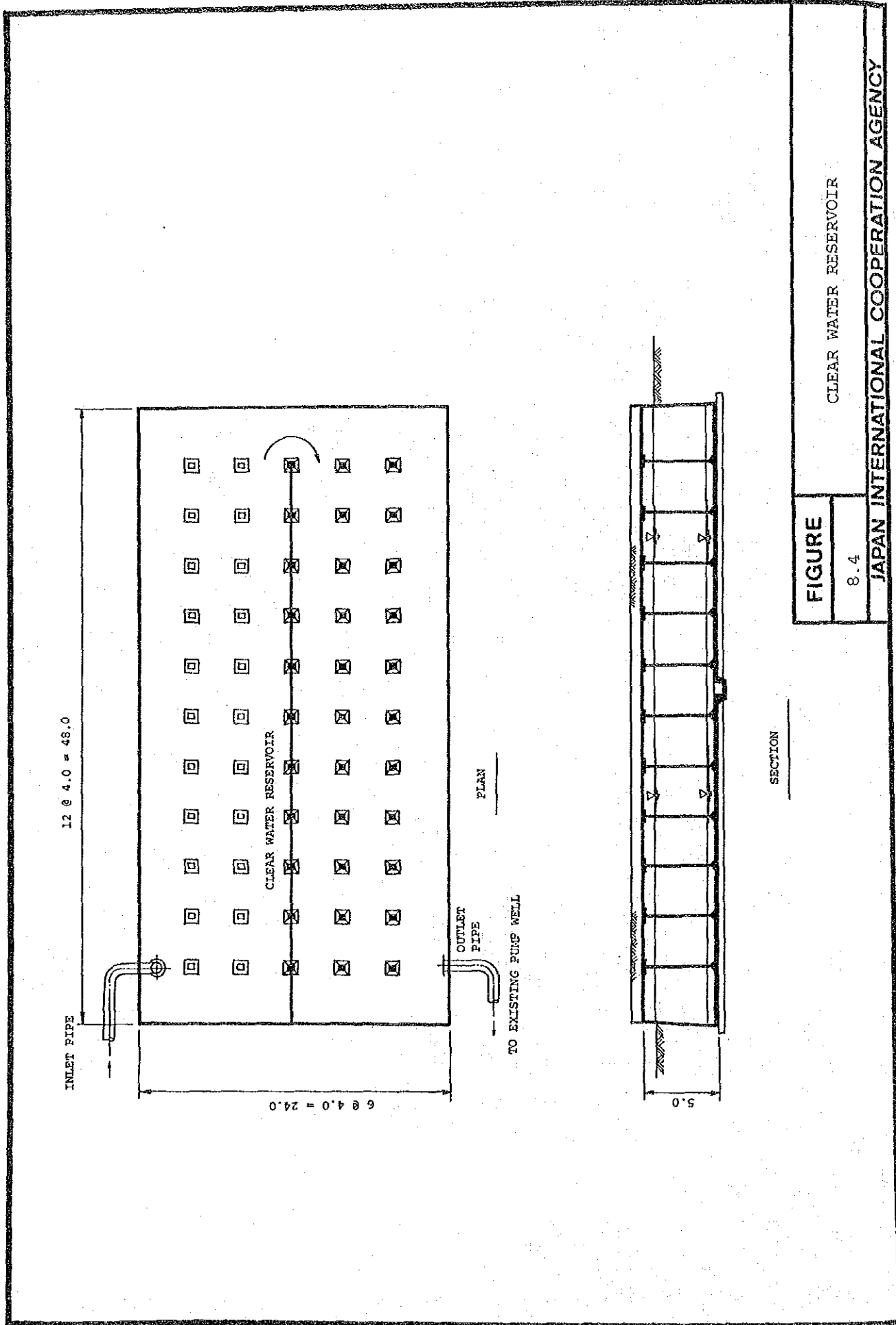
#### 8.2.4 Wang Sing Kam Treatment Plant

An additional distribution pump will be installed as 100 % standby to the peak hour flow in 2000.

- Q 3.6 cu m/min x H 20 m x 1 no.



<b>FIGURE</b>	RAPID SAND FILTER
8.3	
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FIGURE

8.4

CLEAR WATER RESERVOIR

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### 8.2.5 Umong Treatment Plant

To serve the peak hour flow in 2000, two additional pumps will be installed including 100 % standby.

Q 10.7 cu m/min x H 20 m x 2 nos.

### 8.2.6 Distribution Pipeline for Chiangmai

As a small area in the western part of the city is located at a higher elevation than other areas, it will be served separately by higher pressure pumps from the Umong Treatment Plant. Most of the other service areas are served by the distribution network receiving water at the pump stations of the three treatment plants.

The hydraulic analysis of the distribution system incorporating proposed pipelines and the existing ones was carried out by means of computer-aided network analysis. Table-8.2 presents results of the analysis. Fig-8.5 shows the land use plan on which areawise water demands are computed.

The routes of distribution pipeline for the target year of 2000 were determined in due consideration of the planned service area and future road planning envisaged in the City Development Plan, and through exchange of views with the officials concerned.

Table-8.3 shows the summary of proposed distribution pipelines based on the results of hydraulic analysis.

Table-8.2 RESULT OF PIPE NETWORK ANALYSIS

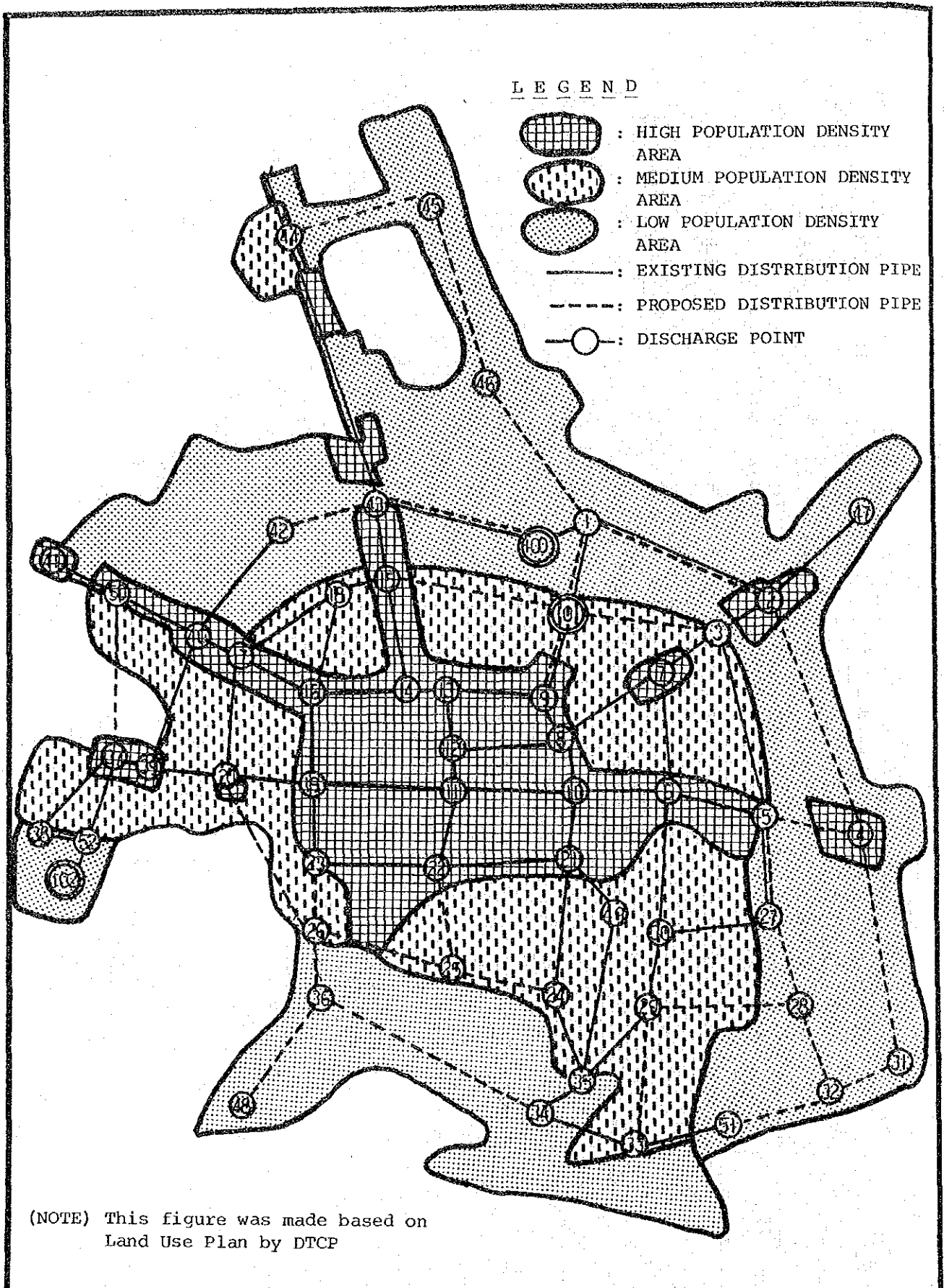
Node - Node	Type	D (mm)	L (m)	C	Q (l/sec)	V (m/sec)	i (o/oo)	dH (m)	Hb/r (m)	H (m)	GL (m)	He (m)
100 - 1	0	619	350	110	391.681	1.302	3.26	1.14	0.00	329.67	310.00	19.67
1 - 2	0	490	1850	110	187.940	0.997	2.61	4.83	0.00	324.84	305.00	19.84
2 - 3	0	363	550	110	58.379	0.564	1.29	0.71	0.00	324.13	310.00	14.13
101 - 3	0	300	1350	110	53.825	0.761	2.82	3.81	0.00	324.13	310.00	14.13
1 - 101	0	471	1000	110	135.930	0.780	1.74	1.74	0.00	327.93	310.00	17.93
2 - 47	0	250	1400	110	16.600	0.338	0.78	1.09	0.00	323.75	300.00	23.75
2 - 4	0	300	2600	110	58.360	0.826	3.27	8.51	0.00	316.33	300.00	16.33
5 - 4	0	150	1000	110	1.645	0.093	0.13	0.13	0.00	316.33	300.00	16.33
3 - 5	0	300	1800	110	67.296	0.952	4.26	7.67	0.00	316.46	305.00	11.46
4 - 31	0	300	2200	110	31.005	0.439	1.02	2.24	0.00	314.09	300.00	14.09
31 - 32	0	200	850	110	18.805	0.599	2.90	2.47	0.00	311.62	300.00	11.62
32 - 28	0	150	900	110	1.386	0.078	0.09	0.09	0.00	311.54	300.00	11.54
27 - 28	0	200	1020	110	12.624	0.402	1.39	1.42	0.00	311.54	300.00	11.54
5 - 27	0	272	880	110	50.100	0.862	3.98	3.50	0.00	312.96	300.00	12.96
3 - 7	0	300	700	110	24.808	0.351	0.67	0.47	0.00	323.66	310.00	13.66
8 - 7	0	300	950	110	13.932	0.197	0.23	0.22	0.00	323.66	310.00	13.66
9 - 8	0	360	350	110	106.061	1.042	4.07	1.42	0.00	323.88	310.00	13.88
101 - 9	0	402	650	110	141.470	1.115	4.05	2.63	0.00	325.30	310.00	15.30
6 - 5	0	150	950	110	10.848	0.614	4.26	4.05	0.00	316.46	305.00	11.46
7 - 6	0	200	1150	110	18.240	0.581	2.74	3.16	0.00	320.50	305.00	15.50
19 - 6	0	250	850	110	34.232	0.697	2.97	2.52	0.00	320.50	305.00	15.50
8 - 10	0	360	550	110	63.002	0.619	1.55	0.85	0.00	323.02	310.00	13.02
27 - 30	0	250	1470	110	17.677	0.360	0.87	1.28	0.00	311.67	300.00	11.67
6 - 30	0	150	1500	110	12.924	0.731	5.89	8.83	0.00	311.67	300.00	11.67
28 - 29	0	150	1550	110	1.810	0.102	0.16	0.24	0.00	311.30	300.00	11.30
30 - 29	0	200	800	110	7.000	0.223	0.47	0.37	0.00	311.30	300.00	11.30
51 - 33	0	250	900	110	5.218	0.106	0.09	0.08	0.00	310.55	300.00	10.55
32 - 51	0	150	900	110	5.218	0.295	1.10	0.99	0.00	310.63	300.00	10.63
29 - 33	0	150	1400	110	3.528	0.200	0.53	0.75	0.00	310.55	300.00	10.55
35 - 29	0	200	1000	110	10.718	0.341	1.03	1.03	0.00	311.30	300.00	11.30
49 - 35	0	200	1200	110	16.591	0.528	2.30	2.76	0.00	312.32	300.00	12.32
21 - 49	0	200	1000	110	28.191	0.897	6.14	6.14	0.00	315.09	305.00	10.09
10 - 21	0	260	750	110	33.821	0.637	2.40	1.80	0.00	321.23	305.00	16.23
24 - 35	0	250	850	110	49.992	1.018	5.98	5.08	0.00	312.32	300.00	12.32
21 - 24	0	250	1250	110	34.803	0.709	3.06	3.82	0.00	317.40	305.00	12.40
34 - 33	0	250	1300	110	17.053	0.347	0.82	1.06	0.00	310.55	300.00	10.55
35 - 34	0	250	750	110	18.466	0.376	0.95	0.71	0.00	311.61	300.00	11.61
100 - 43	0	490	1600	110	199.919	1.060	2.93	4.69	0.00	326.13	310.00	16.13
43 - 44	0	300	2700	110	54.089	0.765	2.85	7.68	0.00	318.45	310.00	8.45
44 - 45	0	200	1500	110	1.389	0.044	0.02	0.04	0.00	318.41	305.00	13.41

(Continued)







Node - Node	Type	D (mm)	L (m)	C	Q (l/sec)	V (m/sec)	i (o/oo)	dH (m)	Hb/r (m)	H (m)	GL (m)	He (m)
46 - 45	0	200	1900	110	21.411	0.682	3.69	7.01	0.00	318.41	305.00	13.41
1 - 46	0	300	1800	110	48.911	0.692	2.36	4.25	0.00	325.42	310.00	15.42
101 - 15	0	300	1750	110	35.035	0.496	1.27	2.23	0.00	325.71	310.00	15.71
43 - 15	0	516	700	110	97.506	0.466	0.60	0.42	0.00	325.71	310.00	15.71
9 - 13	0	200	900	110	12.009	0.382	1.27	1.14	0.00	324.16	310.00	14.16
14 - 13	0	400	350	110	96.895	0.771	2.06	0.72	0.00	324.16	310.00	14.16
15 - 14	0	516	1000	110	115.257	0.551	0.82	0.82	0.00	324.88	310.00	14.88
8 - 12	0	200	1150	110	5.727	0.182	0.32	0.37	0.00	323.51	310.00	13.51
13 - 12	0	400	600	110	68.705	0.547	1.09	0.65	0.00	323.51	310.00	13.51
11 - 10	0	300	1150	110	14.951	0.212	0.26	0.30	0.00	323.02	310.00	13.02
12 - 11	0	400	300	110	49.832	0.397	0.60	0.18	0.00	323.33	310.00	13.33
22 - 21	0	300	1050	110	39.073	0.553	1.56	1.64	0.00	321.23	305.00	16.23
11 - 22	0	400	750	110	50.528	0.402	0.62	0.46	0.00	322.86	310.00	12.86
25 - 24	0	250	1000	110	36.590	0.745	3.35	3.35	0.00	317.40	305.00	12.40
22 - 25	0	300	1100	110	43.647	0.617	1.91	2.10	0.00	320.76	305.00	15.76
36 - 34	0	150	2350	110	8.487	0.480	2.70	6.36	0.00	311.61	300.00	11.61
26 - 36	0	200	850	110	28.287	0.900	6.18	5.25	0.00	317.97	308.00	9.97
26 - 25	0	200	1400	110	14.343	0.457	1.76	2.46	0.00	320.76	305.00	15.76
36 - 48	0	150	1500	110	9.900	0.560	3.60	5.39	0.00	312.58	305.00	7.58
23 - 26	0	250	600	110	23.239	0.473	1.45	0.87	0.00	323.22	310.00	13.22
23 - 22	0	400	1250	110	64.891	0.516	0.98	1.23	0.00	322.86	310.00	12.86
19 - 23	0	423	750	110	118.430	0.843	2.28	1.71	0.00	324.09	310.00	14.09
19 - 11	0	300	1500	110	40.248	0.569	1.65	2.47	0.00	323.33	310.00	13.33
19 - 16	0	300	850	110	25.549	0.361	0.71	0.60	0.00	325.19	310.00	15.19
16 - 14	0	200	900	110	5.939	0.189	0.34	0.31	0.00	324.88	310.00	14.88
18 - 16	0	200	1000	110	3.778	0.120	0.15	0.15	0.00	325.19	310.00	15.19
15 - 18	0	200	640	110	7.783	0.248	0.57	0.36	0.00	325.34	310.00	15.34
17 - 16	0	231	800	110	7.912	0.189	0.29	0.23	0.00	325.19	310.00	15.19
17 - 18	0	200	1400	110	2.295	0.073	0.06	0.08	0.00	325.34	310.00	15.34
40 - 17	0	231	600	110	20.415	0.487	1.68	1.01	0.00	325.43	315.00	10.43
40 - 42	0	150	1120	110	5.675	0.321	1.28	1.44	0.00	324.99	315.00	9.99
43 - 42	0	150	1150	110	4.925	0.279	0.99	1.14	0.00	324.99	315.00	9.99
20 - 26	0	300	1950	110	44.791	0.634	2.01	3.91	0.00	323.22	310.00	13.22
20 - 19	0	545	750	110	202.327	0.867	1.78	1.34	0.00	325.80	310.00	15.80
20 - 17	0	150	1100	110	6.291	0.355	1.55	1.71	0.00	325.43	315.00	10.43
39 - 20	0	545	700	110	269.610	1.156	3.03	2.12	0.00	327.13	315.00	12.13
39 - 40	0	300	1300	110	46.790	0.662	2.18	2.83	0.00	326.43	315.00	11.43
102 - 52	0	500	500	110	330.100	1.681	6.71	3.36	0.00	336.64	325.00	11.64
52 - 39	0	500	1100	110	330.100	1.681	6.71	7.38	0.00	329.26	315.00	14.26

UMONG HIGH ELEVATION AREA

Node - Node	Type	D (mm)	L (m)	C	Q (l/sec)	V (m/sec)	i (o/oo)	dH (m)	Hb/r (m)	H (m)	GL (m)	He (m)
102 - 52	0	300	500	110	76.800	1.086	5.44	2.72	0.00	352.28	330.00	22.28
52 - 37	0	300	800	110	53.259	0.753	2.76	2.21	0.00	350.07	330.00	20.07
37 - 38	0	200	1500	110	7.859	0.250	0.58	0.87	0.00	349.20	340.00	9.20
52 - 38	0	200	700	110	23.541	0.749	4.40	3.08	0.00	349.20	340.00	9.20
37 - 50	0	250	1700	110	35.000	0.713	3.09	5.25	0.00	344.81	323.00	21.81
50 - 41	0	200	900	110	14.300	0.455	1.75	1.57	0.00	343.24	330.00	13.24



LEGEND

-  : HIGH POPULATION DENSITY AREA
-  : MEDIUM POPULATION DENSITY AREA
-  : LOW POPULATION DENSITY AREA
-  : EXISTING DISTRIBUTION PIPE
-  : PROPOSED DISTRIBUTION PIPE
-  : DISCHARGE POINT

(NOTE) This figure was made based on  
Land Use Plan by DTCP

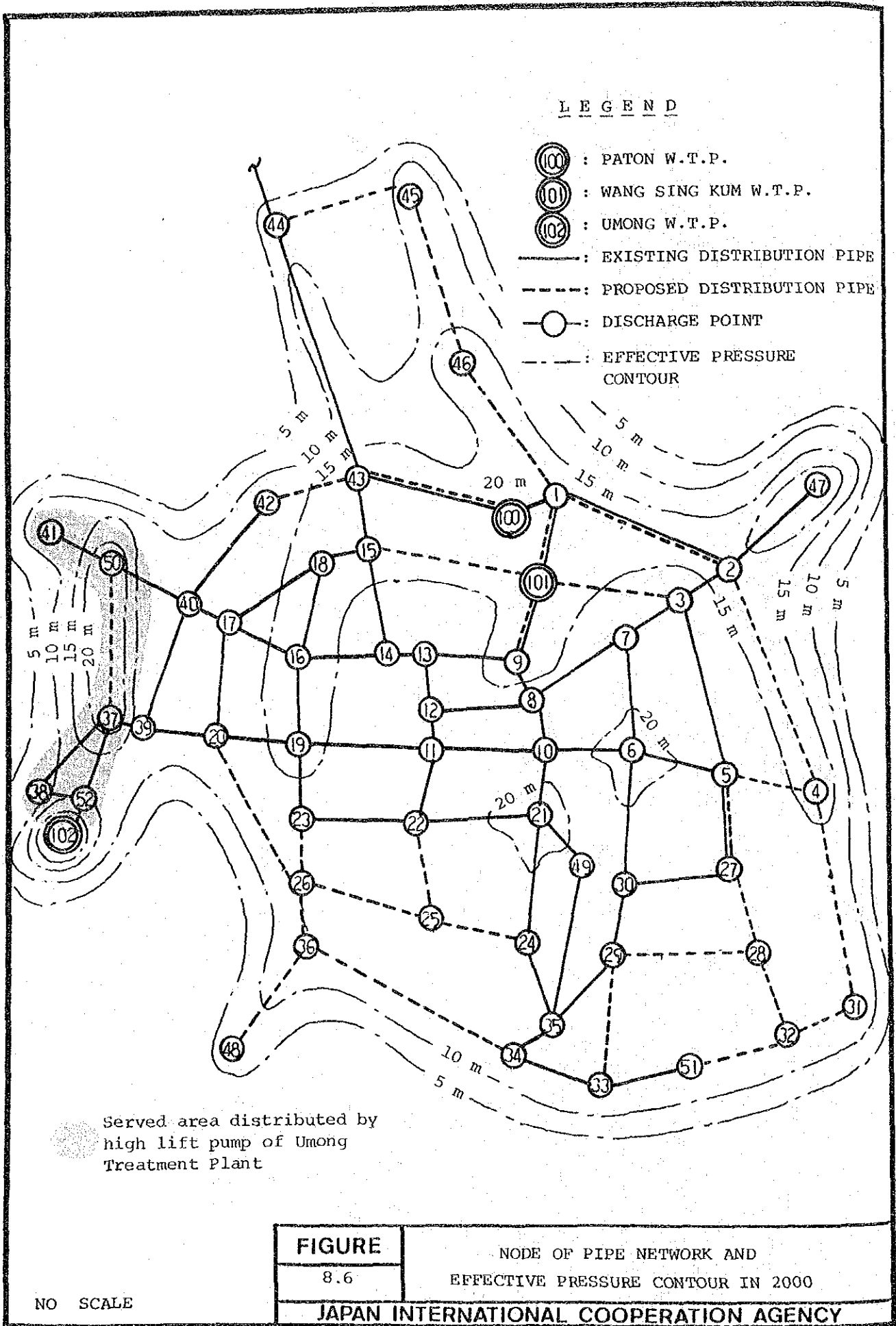
<b>FIGURE</b>	POPULATION DENSITY IN YEAR 2000
8.5	
<b>JAPAN INTERNATIONAL COOPERATION AGENCY</b>	

NO SCALE

Table- 8.3 PROPOSED DISTRIBUTION  
PIPELINES

DIAMETER (mm)	LENGTH (m)
500	350
400	4,450
300	13,400
250	3,300
200	7,520
150	24,700
100	51,500
Total	105,220

As a result of hydraulic analysis of the distribution network, the area will be served with 1.0 to 2.0 kg/sq cm service pressure as shown in Fig- 8.6 except the nodes 44 and 48 where during the peak hour, the service pressure is expected to decrease to 0.85 and 0.76 kg/sq cm respectively. A particular measure will not be provided to increase the service pressure at the node 48 since the pressure drop is considered not critical.



APPENDIX 9

COST DATA AND CONSTRUCTION COST





APPENDIX 9 COST DATA AND CONSTRUCTION COST

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## APPENDIX 9

### 9.1 Cost Data

#### 9.1.1 Cost Data Collection

PWA has its own standard price list of materials, products and works. In this estimate, the prices of listed items were quoted directly.

Regarding unlisted items, estimation was made by illation from related prices in the list.

Market prices of the materials and products to be used in the estimation were collected and quoted when found applicable reasonably.

Prices of some products and equipments were quoted by the suppliers and manufacturers were used in the estimation.

#### 9.1.2 Pipelaying Cost

As pipelaying constitutes major part of this project, the cost is detailed in this sub-section.

Three assumptions are made in estimating pipelaying.

The first is that the 20 and 80 % of the total length of a pipeline are allocated to ductile-iron and asbestos-cement pipe respectively.

The second is that 10 % of the estimated cost including pipes, fittings and laying works is counted for railroad crossing, riverbed crossing and pipe bridge additionally.

The third is that 15 % of the estimated cost as above is counted for installation of valves, concrete thrust blocks and other miscellaneous works.

Table-9.1 (a) Unit Cost of Pipelaying (ACP)

(Unit: P/m)

Dia. (mm)	Labor	Pipe Material	Sub-Total	Pavement	Total
100	47	140	187	140	327
150	66	230	296	154	450
200	80	398	478	166	644
250	111	551	662	179	841
300	146	780	926	223	1,149
400	181	1,478	1,659	248	1,907
500	261	2,050	2,311	283	2,594
600	338	2,703	3,041	319	3,360

Table-9.1 (b) Unit Cost of Pipelaying (DIP)

(Unit: P/m)

Dia. (mm)	Labor	Pipe Material	Sub-Total	Pavement	Total
100	53	504	557	140	697
150	87	723	810	154	964
200	98	972	1,070	166	1,236
250	135	1,224	1,359	179	1,538
300	179	1,596	1,775	223	1,998
350	197	1,917	2,114	236	2,350
400	221	2,346	2,567	248	2,815
450	266	2,839	3,105	266	3,371
500	318	3,362	3,680	283	3,963
600	413	4,505	4,918	319	5,237
700	515	5,897	6,412	341	6,753
800	629	7,414	8,043	378	8,421
900	749	9,122	9,871	402	10,273
1,000	873	11,053	11,926	436	12,362
1,100	1,001	13,086	14,087	470	14,557
1,200	1,125	15,175	16,300	504	16,804

Table-9.1 (a) and (b) show the cost of unit length (meter) of pipelaying for asbestos-cement and ductile-iron pipes including pipes, fittings, labor and pavement restoration.

#### 9.1.3 Treatment Plant, Buildings and Others

In estimating approximately the construction cost of treatment plant and buildings used for administration and others in the plant site, the cost function graphs shown in Fig-9.1 are used.

To prepare the cost function curves, production capacities and construction costs of seven PWA treatment plants plotted and the curves are drawn as most appropriate. Similar data made by other consultants were also referred for comparison.

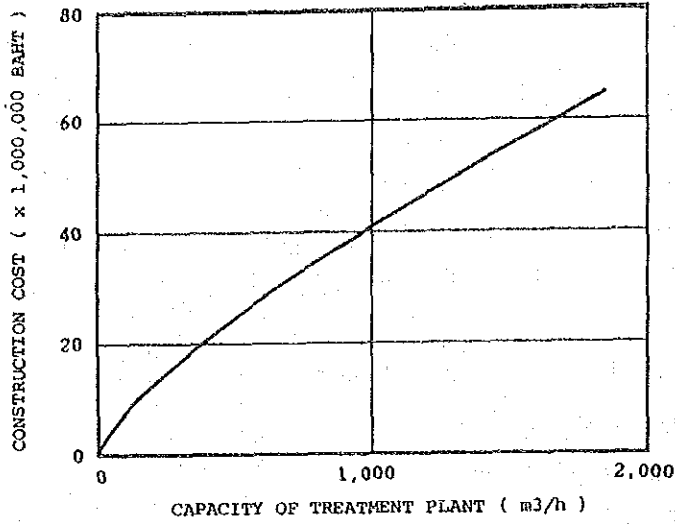
The approximately estimated costs were checked with the costs prepared by calculating, item by item, components of the whole construction work involved in the PWA standard design and the both were found close satisfactorily.

For other construction works like deep well, available data were studied and modification was made by illation from them.

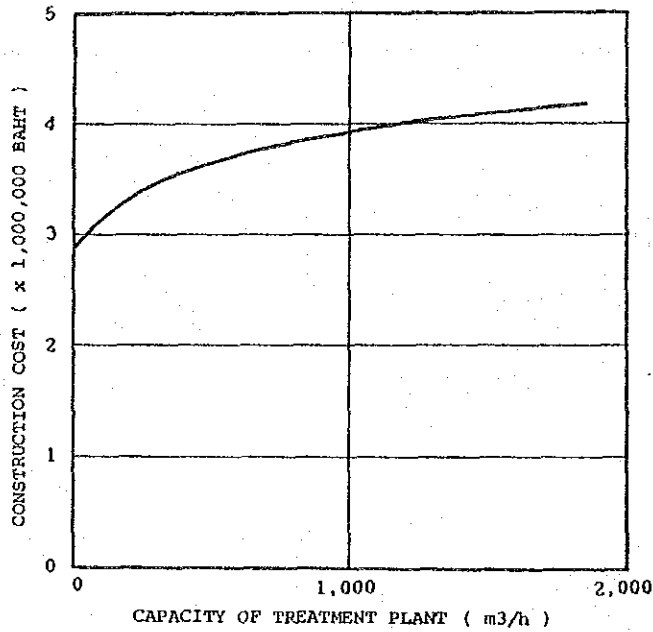
#### 9.1.4 Land Acquisition

Land price of the prospective sites of treatment plants, pump stations and other facilities under this plan were estimated based on the contacts with PWA local officials.

TREATMENT PLANT



BUILDINGS FOR ADMINISTRATION AND OTHER USES



<b>FIGURE</b>	COST FUNCTION OF TREATMENT PALNT AND BUILDINGS FOR ADMINISTRATION AND OTHER USES
9.1	
JAPAN INTERNATIONAL COOPERATION AGENCY	

## 9.2 Classification of Works

Every work involved in the project is to be classified into either one of the following six:

1. Pipelaying works : laying pipes above- and under-ground
2. Civil works : construction of barrage, grit chamber, clear water reservoir, intake tower, and earthwork, groundwork
3. Treatment plant construction : inclusive of 1, 2 and 5
4. Pump station construction : inclusive of 1, 2, 5 and architectural works
5. Equipment/machinery installation
6. Purchase of equipment/machinery

This classification is used in making allocation of foreign and local currency portion in the following section and in Table-9.2 listed later.

## 9.3 Costs allocation of Foreign and Local Currency Portions

All of the estimated costs are allocated to two currency portions, foreign and local, and to each of the six works classified before an appropriate ratio is to be applied.

### 9.3.1 Basic Conception

Those products which are imported as finished and do not need further processing in Thailand are considered to be of 100 % foreign currency portion.

Labor, both skilled and unskilled, and services locally procured are considered to be 100 % local currency portion.

In between the above two extremes, a certain appropriate ratio is applied upon consideration of the characteristic of item.

Even the majority of domestically made materials and products contain foreign currency portion. Cement and steel are made by consuming imported fuel and electricity, generated by imported fuel. Equipments and machineries producing these materials are imported sometimes. The asbestos-cement pipe, a local product, is made of imported asbestos.

Earthwork and concrete mixing and casting made by laborers in former days are worked by machineries, using foreign currency partly.

#### 9.3.2 Foreign and Local Currency Elements

The foreign currency elements are imported raw and processed materials, equipments and machineries, consumable goods including fuel, etc.

The local currency elements are local raw materials, skilled and unskilled labors used directly or indirectly, for instance, further processing of imported goods, etc.

#### 9.3.3 Combination of Foreign and Local Currency Elements

Of the six classified works, Fig-9.2 (1) to (6) shows how the foreign and local currency elements are combined to construct them.

The six figures are then summarized and shown in Table-9.2.

Seen in the table are:

- 1) The foreign currency portion increases in the order of the item number.



- 2) The locally processed portion is largest in treatment plant construction and smallest in equipment/machinery installation, as it involves installation of imported goods finished to higher degree.
- 3) The skilled labor portion is also highest in treatment plant construction and civil works.
- 4) The unskilled labor portion decreases in the order of the item number.
- 5) The sum of labor portions also decreases in the order of the item number, corresponding the labor-intensiveness of those works.

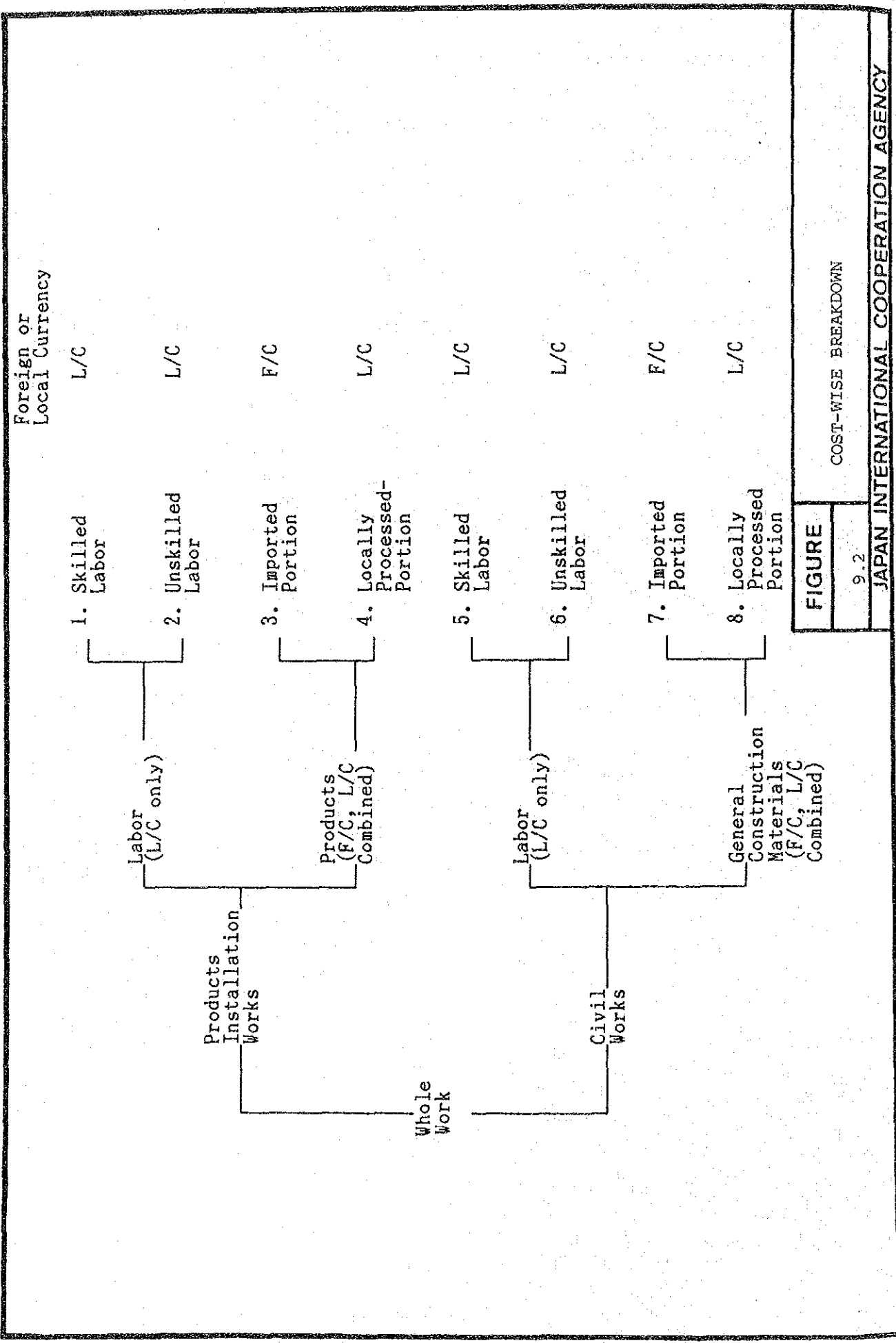
Table-9.2 ALLOCATION OF FOREIGN AND LOCAL CURRENCY PORTIONS

No.	Works Description	F/C Portion	L/C Portion		
			Locally Processed Portion	Skilled Labor	Unskilled Labor
1.	Pipelaying	60	10	14	16
2.	Civil works	63	11	12	14
3.	Treatment Plant Construction	66	12	12	10
4.	Pump Station Construction	75	10	7	8
5.	Equipments/ Machinery Installation	85	5	7	3
6.	Equipments/ Machinery Purchase	100	0	0	0

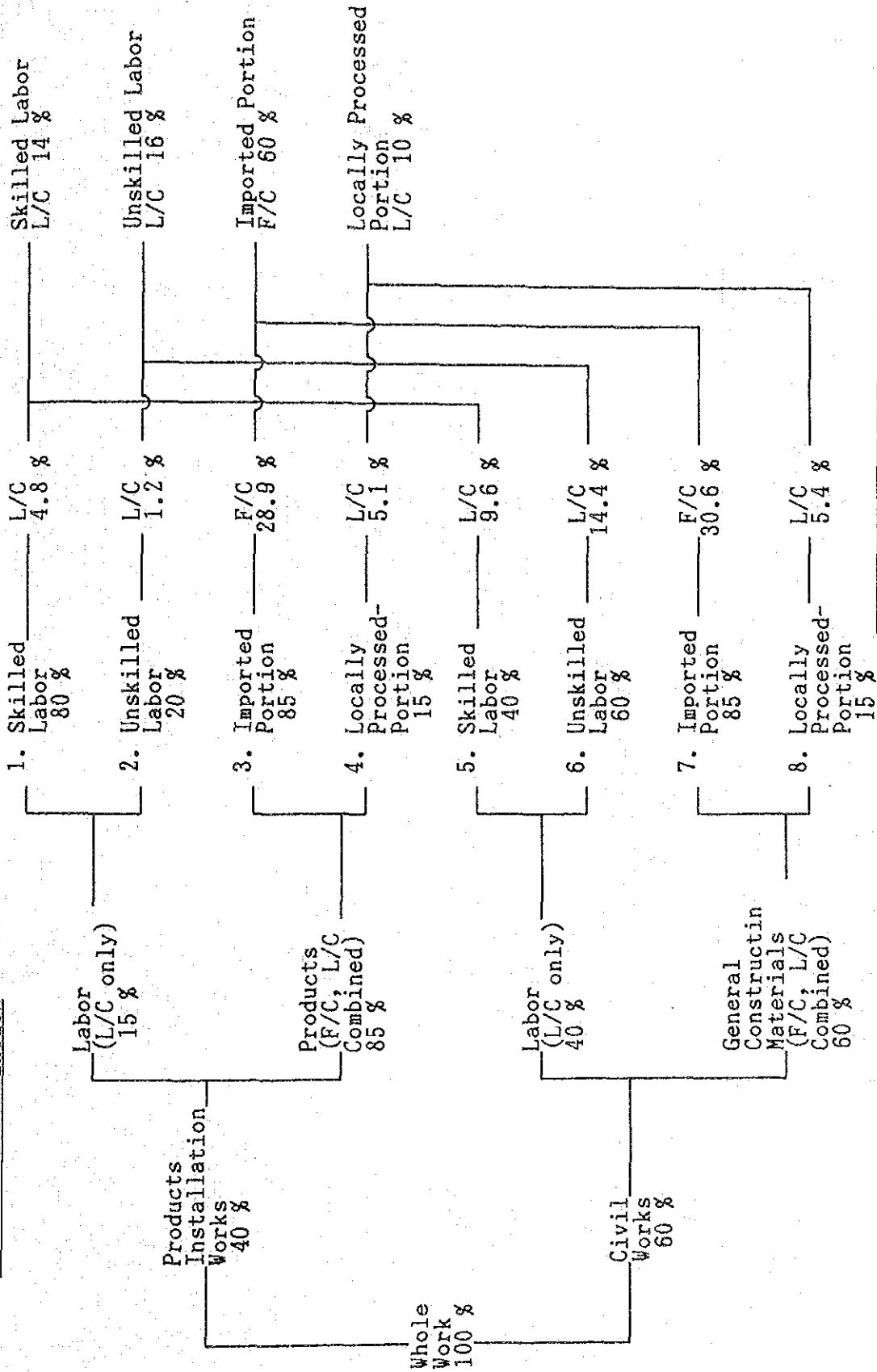
#### 9.4 Construction Cost

Using the cost data mentioned in 9.1, estimation was made on Rehabilitation and Modification Works and Expansion Works planned for Stage I.

It is shown in Table-9.3.



No. 1 PIPE AND INSTALLATION



FIGURE

9.3 (1)

COST-WISE BREAKDOWN FOR PIPE AND INSTALLATION

JAPAN INTERNATIONAL COOPERATION AGENCY

No. 2 CIVIL WORKS

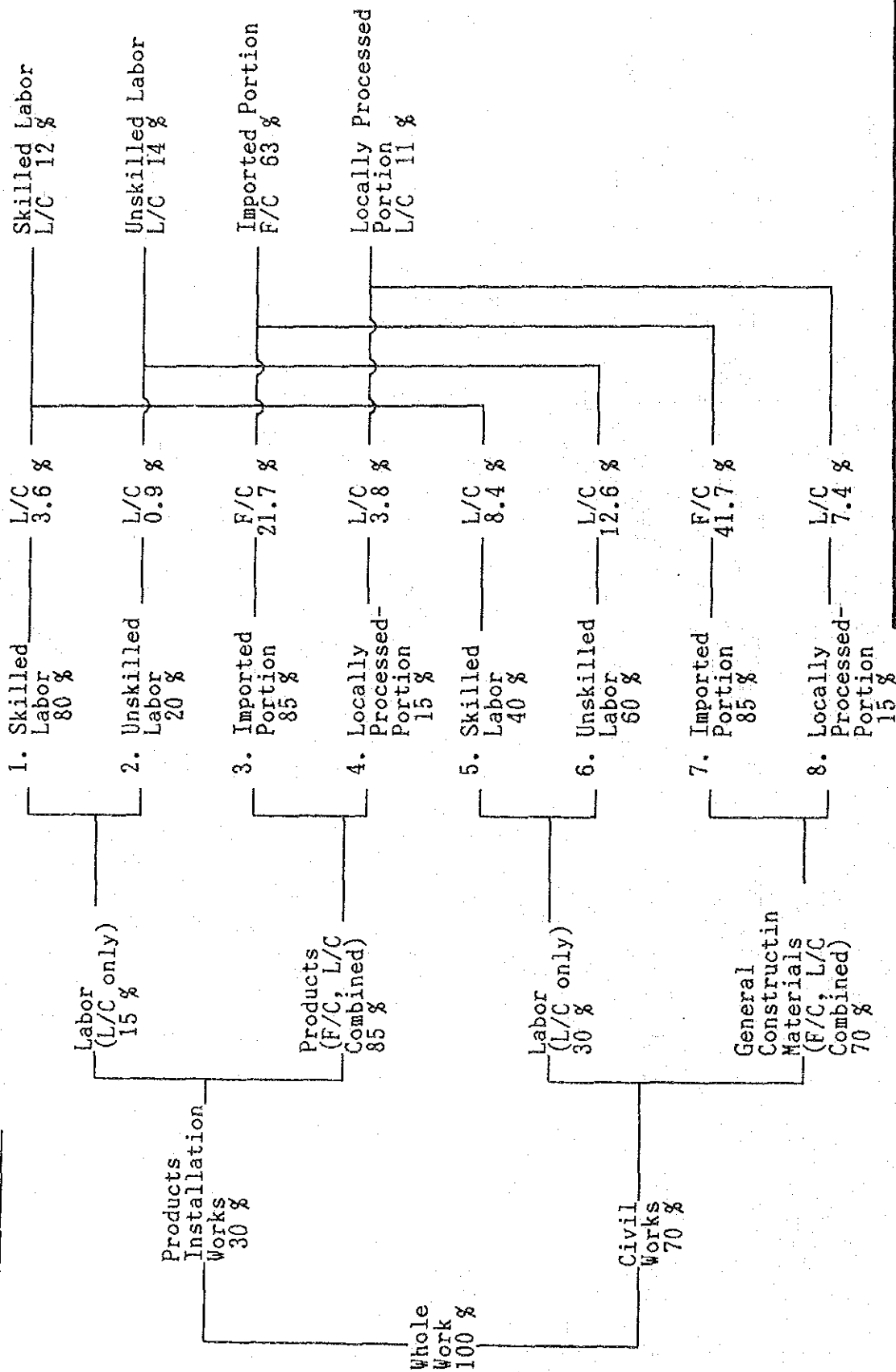
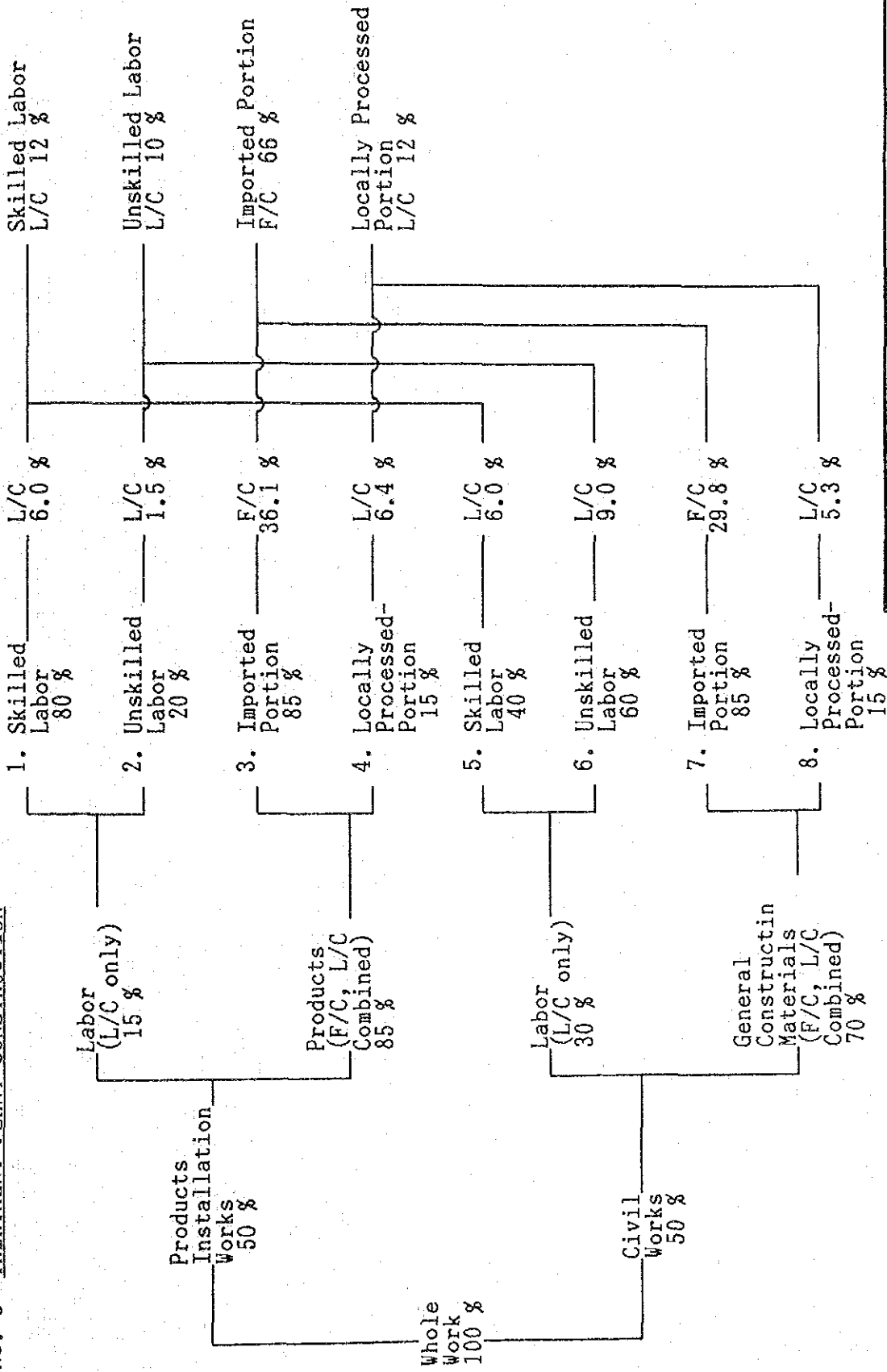


FIGURE 9.3 (2) COST-WISE BREAKDOWN FOR CIVIL WORKS JAPAN INTERNATIONAL COOPERATION AGENCY

No. 3 TREATMENT PLANT CONSTRUCTION

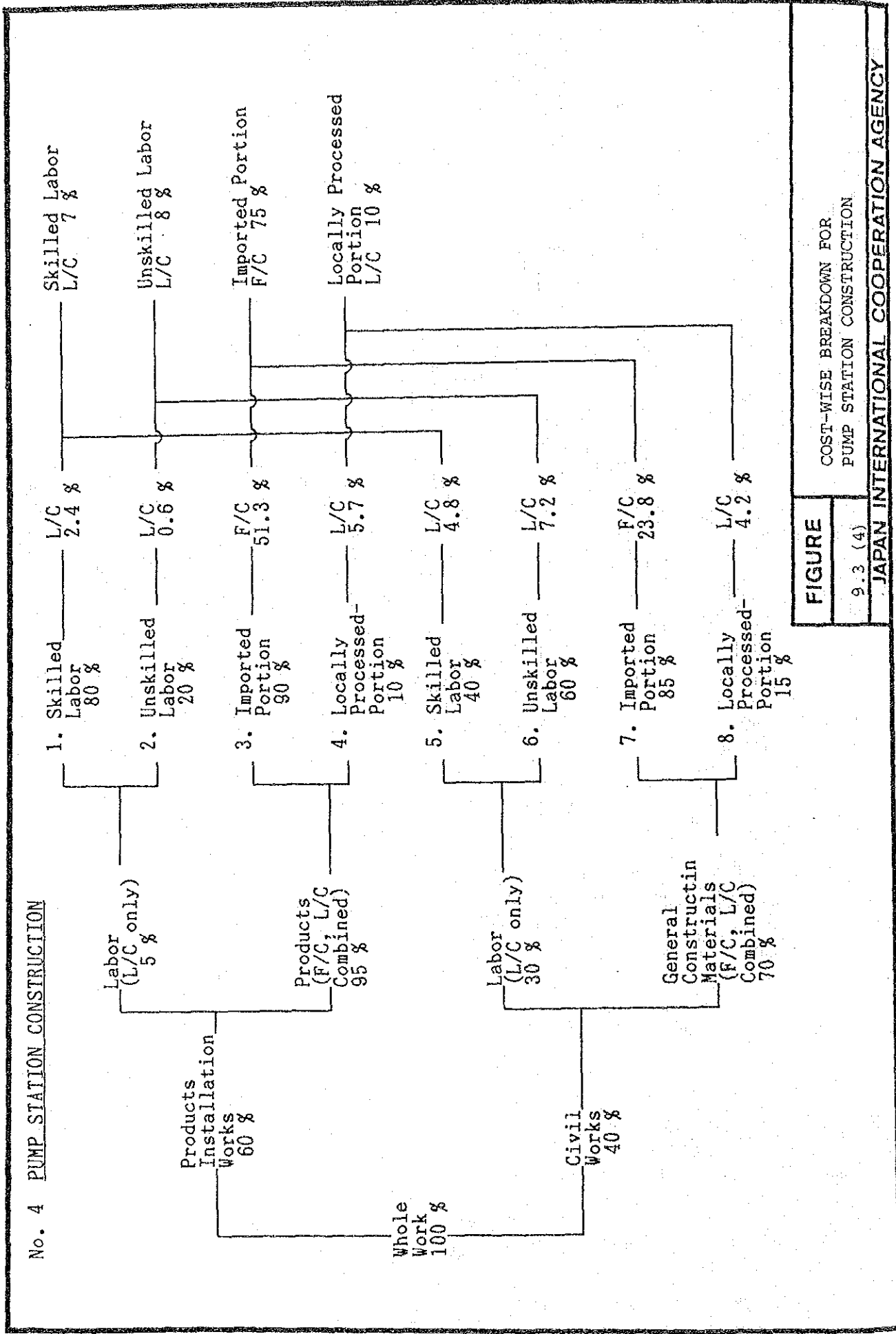


FIGURE

COST-WISE BREAKDOWN FOR TREATMENT PLANT CONSTRUCTION

9.3 (3)

JAPAN INTERNATIONAL COOPERATION AGENCY



**FIGURE**

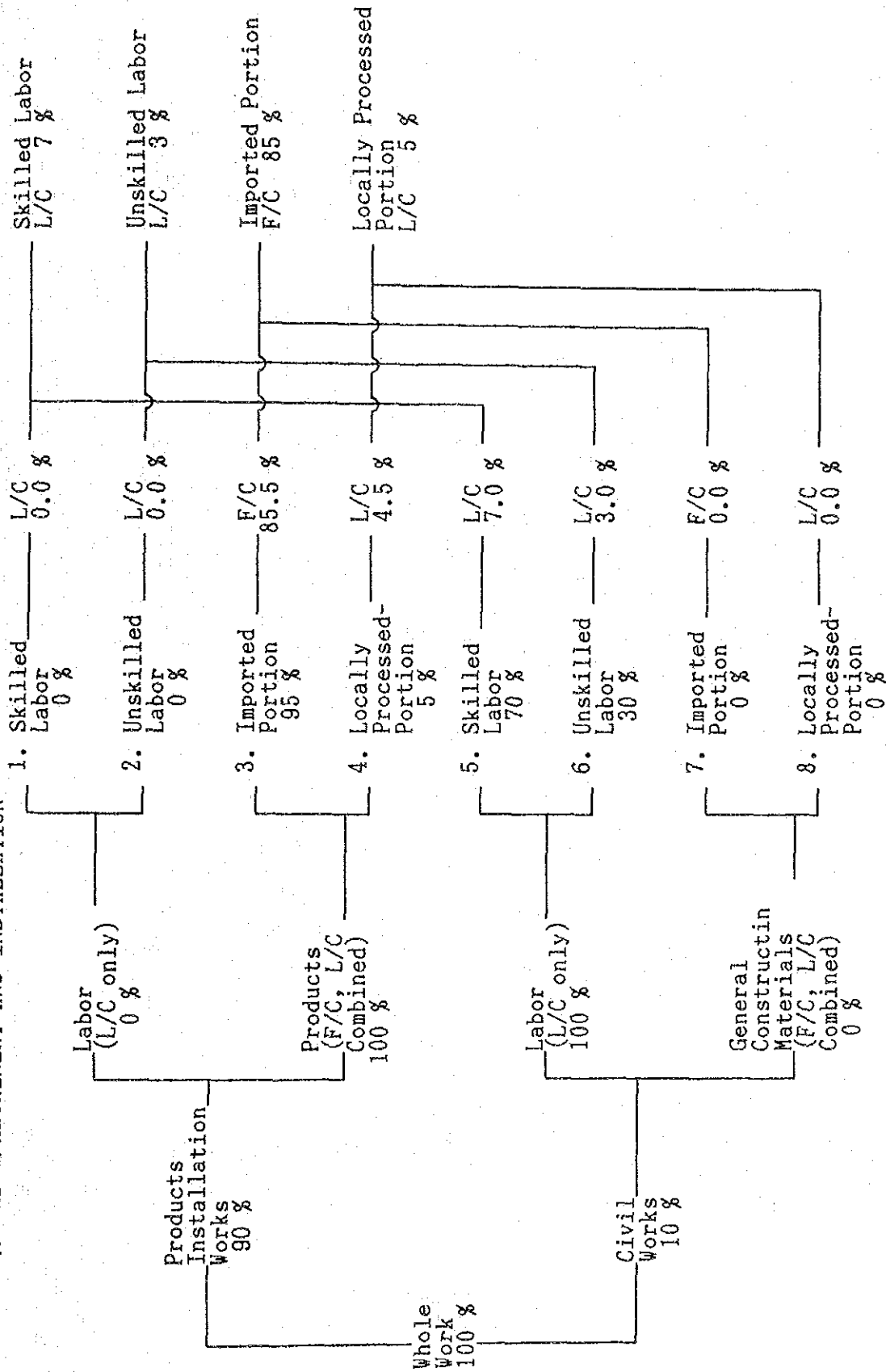
9.3 (4)

COST-WISE BREAKDOWN FOR  
PUMP STATION CONSTRUCTION

JAPAN INTERNATIONAL COOPERATION AGENCY



No. 5 EQUIPMENT/MACHINERY AND INSTALLATION

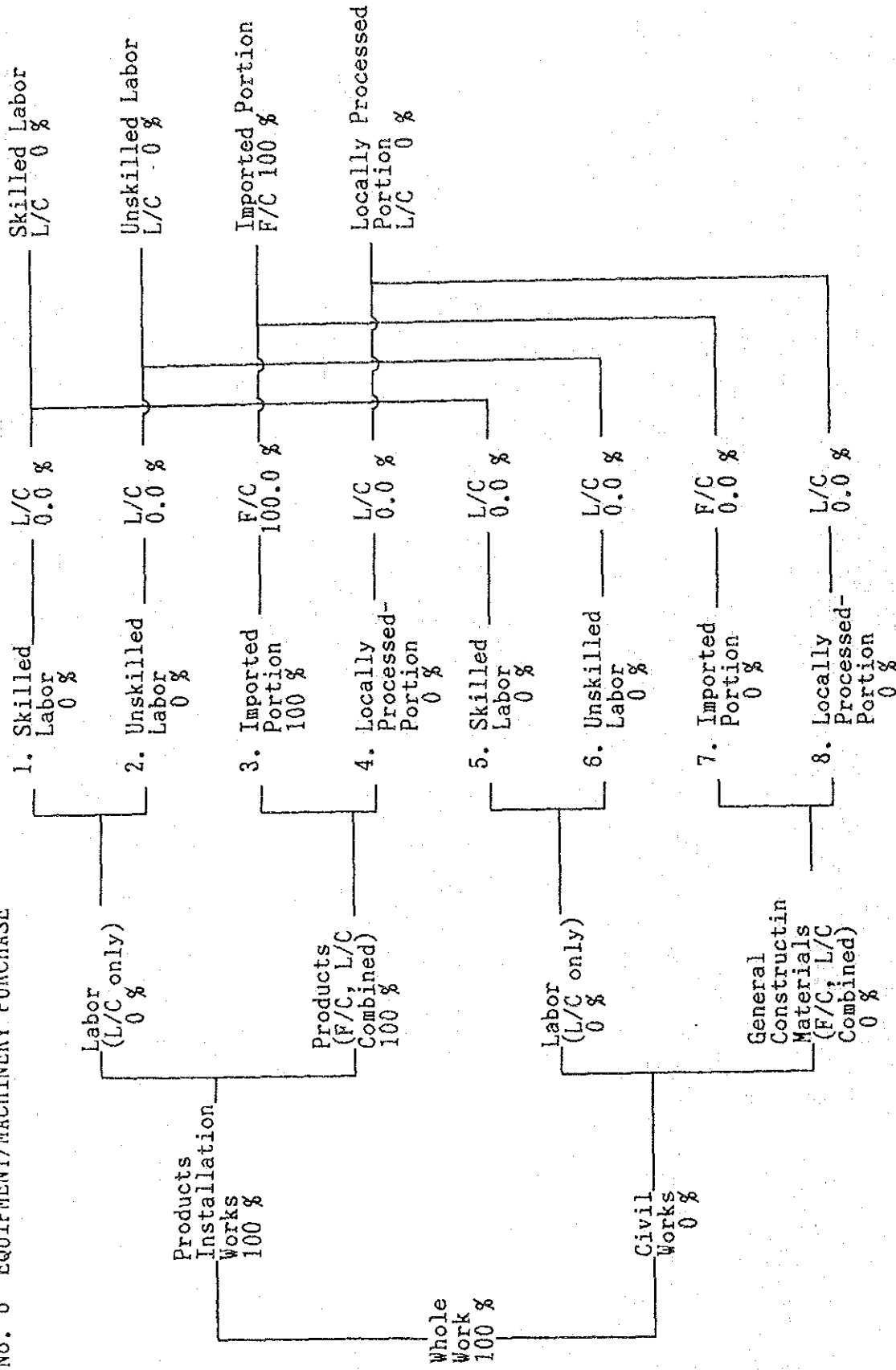


FIGURE

9.3 (5)

COST-WISE BREAKDOWN FOR  
EQUIPMENT/MACHINERY AND INSTALLATION  
JAPAN INTERNATIONAL COOPERATION AGENCY

No. 6 EQUIPMENT/MACHINERY PURCHASE



FIGURE

COST-WISE BREAKDOWN FOR  
EQUIPMENT/MACHINERY PURCHASE

9.3 (6)

JAPAN INTERNATIONAL COOPERATION AGENCY

Table-9.3 (a) CONSTRUCTION COST

(x 1,000 Baht)

Work item	Description	Quantity	Unit Cost	Cost
<b>I. Stage I Rehabilitatin/Modification Works</b>				
1. Land Acquisition	-	-	-	-
	<b>T o t a l 1</b>			-
2. Intake & Treatment Plant				
1) Chiangmai				
(1) Ban Tho Intake	a) Intake Pump	2	233	466
	Miscelleneous	L. S.		534
	b) Flow Meter and Recorder	2	600	1,200
	Dia. 600 mm and 300 mm			
	Sub Total (1)			2,200
(2) Treatment Plant	a) Wang Sing Kam T.P.	L. S.		4,002
	(See Table-9.3 (b))			
	b) Umong T.P.	L. S.		5,632
	(See Table-9.3 (b))			
	c) Paton T.P.	L. S.		7,466
	(See Table-9.3 (b))			
	Sub Total (2)			17,100
	Sub Total 1)			19,300
2) Mae Rim & San Kam.				
(1) Treatment Plant	a) Chlorine gas container scale	2	200	400
	Sub Total (1)			400
	Sub Total 2)			400
	<b>T o t a l 2</b>			19,700
3. Distribution Pipeline				
1) Chiangmai				
(1) Pipe Replacement	a) ACP 150 mm Dia.	2,900	0.45	1,305
	b) ACP 100 mm Dia.	1,850	0.327	605
	c) Miscellaneous Works	L. S.		340
	Sub Total (1)			2,250
(2) Leak Detection Equipment	a) Metal Pipe Detector	1	80	80
	b) Non-Metal Pipe Detector	1	200	200
	c) Box Locator	1	20.000	20
	d) Leak Detector	2	60	120
	e) Stethoscopic Bar	2	3	6
	f) Spare Parts	L. S.		24
	Sub Total (2)			450
	<b>T o t a l 3</b>			2,700
<b>Stage I Rehabilitatin/Modification Works TOTAL</b>				<b>22,400</b>

Work Item	Description	Cont'd		Cost
		Quantity	Unit Cost (x 1,000 Baht)	
<b>II. Stage I Expansion Works</b>				
1. Land Acquisition	a) Ban Tho Intake 2,300 m <sup>2</sup>	2,300	0.8	1,800
	Total 1			1,800
<b>2. Chiangmai Facilities</b>				
1) Ban Tho Intake				
(1) Barrage	a) Barrage Height : 1.5 m	L. S.		6,363
	b) Gate with headstock	3	1500	4,500
	c) Access bridge	L. S.		137
	Sub Total (1)			11,000
(2) Grit Chamber	a) Chamber : 2 basins	2	600	1,200
	b) Screen (Manual)	2	100	200
	c) Gate	4	300	1,200
	d) Travelling desludging pump	1	800	800
	e) Miscellaneous works	L. S.		700
	Sub Total (2)			4,100
(3) Raw Water Pump Station	a) Pump house 7 m x 20 m = 140 m <sup>2</sup>	140	4	560
	b) Pump Q15.3 m <sup>3</sup> /min x H47 m			
	Motor drive type	1	665	665
	Motor & engine drive type	1	1600	1,600
	c) Miscellaneous works	L. S.		2,975
	Sub Total (3)			5,800
	Sub Total 1)			20,900
2) Raw Water Transmission Pipeline	a) DIP Dia. 500 x 620 m	620	3.963	2,457
	b) ACP Dia. 500 x 20480 m	2,480	2.594	6,433
	c) Miscellaneous works	L. S.		1,310
	Sub Total 2)			10,200
3) Paton Treatment Plant	Plant capacity : 20,000 m <sup>3</sup> /d (840 m <sup>3</sup> /h)			
	a) Civil work of treatment plant	L. S.		36,000
	b) Building for administration and others	L. S.		3,900
	c) Instrumentation facilities	L. S.		3,600
	d) Miscellaneous works	L. S.		5,400
	Sub Total a) - d)			48,900
	e) Clear water reservoir (5,000 m <sup>3</sup> )	5,000	1.7	8,500
	Miscellaneous works	L. S.		1700
	Sub Total e)			10,200
	f) Distribution pump Q13.9 m <sup>3</sup> /min x H30 m			
	Motor drive type	1	480	480
	Motor & engine drive type	1	1000	1000
	Piping and miscellaneous works	L. S.		820
	Sub Total f)			2,300
	Sub Total 3)			61,400
4) Wang Sing Kam T.P.	a) Distribution pump Q3.6 m <sup>3</sup> /min x H20 m			
	Motor & engine drive type	1	350	350
	Piping and miscellaneous works	L. S.		350
	Sub Total a)			700
	Sub Total 4)			700
5) Umong T.P.	a) Distribution pump Q10.7 m <sup>3</sup> /min x H20 m			
	Motor drive type	1	263	263
	Motor & engine drive type	1	580	580
	Piping and miscellaneous works	L. S.		457
	b) Pump pit 5m x 10 m x Depth 4 m = 200 m <sup>3</sup>	200	2.5	500
	Sub Total 5)			1,800

Cont'ed (x 1,000 Baht)

Work item	Description	Quantity	Unit Cost	Cost
6) Distribution Pipeline	a) DIP Dia. 500 mm x 70 m	70	3.963	277
	b) ACP Dia. 500 mm x 280 m	280	2.594	726
	c) DIP Dia. 400 mm x 890 m	890	2.815	2,505
	d) ACP Dia. 400 mm x 3,560 m	3,560	1.907	6,789
	e) DIP Dia. 300 mm x 2,680 m	2,680	1.998	5,355
	f) ACP Dia. 300 mm x 10,720 m	10,720	1.149	12,317
	g) DIP Dia. 250 mm x 660 m	660	1.538	1,015
	h) ACP Dia. 250 mm x 2,640 m	2,640	0.841	2,220
	i) DIP Dia. 200 mm x 1,500 m	1,500	1.236	1,854
	j) ACP Dia. 200 mm x 6,020 m	6,020	0.644	3,877
	k) ACP Dia. 150 mm x 24,700 m	24,700	0.45	11,115
	l) ACP Dia. 100 mm x 51,500 m	51,500	0.327	16,841
	m) Pipe bridge and road crossing works	L. S.		6,488
	n) Miscellaneous works	L. S.		9,720
	Sub Total 6)			81,100
	T o t a l 2			176,100
3. Mae Rim Facilities				
1) Raw Water Transmission Pipeline	a) DIP Dia. 300 mm x 180 m	180	1.998	360
	b) ACP Dia. 300 mm x 720 m	720	1.149	827
	c) Miscellaneous works	L. S.		213
	Sub Total 1)			1,400
2) Distribution Pipeline	a) DIP Dia. 300 mm x 260 m	260	1.998	519
	b) ACP Dia. 300 mm x 1,040 m	1,040	1.149	1,195
	c) DIP Dia. 200 mm x 2,220 m	2,220	1.236	2,744
	d) ACP Dia. 200 mm x 8,880 m	8,880	0.644	5,719
	e) ACP Dia. 150 mm x 3,400 m	3,400	0.45	1,530
	f) ACP Dia. 100 mm x 5,200 m	5,200	0.327	1,700
	g) Pipe bridge and road crossing works	L. S.		1,341
	h) Miscellaneous works	L. S.		2,052
	Sub Total 2)			16,800
	T o t a l 3			18,200
4. San Kamphaeng Facilities				
1) Distribution Pipeline	a) DIP Dia. 300 mm x 100 m	100	1.998	200
	b) ACP Dia. 300 mm x 400 m	400	1.149	460
	c) DIP Dia. 250 mm x 220 m	220	1.538	338
	d) ACP Dia. 250 mm x 880 m	880	0.841	740
	e) DIP Dia. 200 mm x 240 m	240	1.236	297
	f) ACP Dia. 200 mm x 960 m	960	0.644	618
	g) ACP Dia. 150 mm x 2,900 m	2,900	0.45	1,305
	h) ACP Dia. 100 mm x 3,400 m	3,400	0.327	1,112
	i) Pipe bridge and road crossing works	L. S.		507
	j) Miscellaneous works	L. S.		723
	T o t a l 4			6,300
Stage I Expansion Works	TOTAL			202,400
GRAND TOTAL ( I + II )				224,800

Table-3.3 (b) CONSTRUCTION COST (REHABILITATION/MODIFICATION WORKS FOR TREATMENT PLANT)

(x 1,000 Baht)

Work item	Description	Unit	Wang Sing Kaw		Uwong		Paton		Total	
			Cost	Qty.	Cost	Qty.	Cost	Qty.		Cost
1. Chemical Feeding Equipment	1) Alum	15	2	30	-	-	1	15	45	
	a) Solution tank	85	2	170	2	170	2	170	510	
	b) Feeding pump			L.S.	200	L.S.	180	L.S.	200	580
	c) Appurtenances									
	2) Line	15	2	30	2	30	2	30	90	
	a) Solution tank	71	2	142	2	142	2	142	426	
	b) Feeding pump			L.S.	180	L.S.	180	L.S.	180	549
	c) Appurtenances									
	Total 1				752		702		746	2,200
	2. Level Gage & Flow Meter	1) Level gage	200	2	400	2	400	2	400	1,200
2) Water flowmeter and recorder		550	2	1,100	1	550	-	-	-	
Total 2				1,500		950		400	2,850	
3. Chlorine Gas Container Scale	1) Scale	300	1	300	1	300	-	-	600	
	Total 3			300		300		-	600	
4. Filter Media and Underdrain	1) Washing of filter media			L.S.	90	L.S.	470	L.S.	240	800
	2) Repair of underdrain			L.S.	560	L.S.	3,010	L.S.	1,530	5,100
	Total 4				650		3,480		1,770	5,900
5. Distribution Pump	1) Q7.2 m <sup>3</sup> /min x H20 m	213	1	213	-	-	-	-	213	
	2) Q3.6 m <sup>3</sup> /min x H20 m	159	1	159	-	-	-	-	159	
	3) Q13.9 m <sup>3</sup> /min x H30 m	480	-	-	-	-	2	960	960	
	4) Miscellaneous works	L.S.		428	-	-	L.S.	1,040	1,468	
	Total 5			800		-		2,000	2,800	
6. Drain Pipe of Sedimentation Basin	Drain pipe Dia. 100 mm	10	-	-	20	200	-	-	200	
	Total 6			-		200		-	200	
7. Hanging Net of Sedimentation Basin	W3.5 m x D3.0 m x 10 nets			-	-	-	L.S.	100	100	
	Total 7			-		-		100	100	
8. Headstock of Filter Washing Valves	Total 8	100	-	-	-	-	18	1,800	1,800	
9. Filter Sand Washer	For Chiangmai Waterworks	650	-	-	-	-	1	650	650	
	Total 9			-		-		650	650	
GROUND TOTAL					4,002		5,632		7,466	17,100

APPENDIX 10

FINANCIAL AND ECONOMIC STUDY





APPENDIX 10 FINANCIAL AND ECONOMIC ANALYSIS

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Table-10.1 CASH FLOW PROJECTED (x 1,000 Baht) AT 1986 PRICE. (CHIANGMAI WATERWORKS)

Description	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
(A) Water Production (x1000 m3)	14,754	15,557	16,240	16,947	17,659	18,493	19,496	20,341	21,253	21,949	22,593	23,277	23,943	24,530	25,199
(B) Unaccounted for Water (%)	31	30	29	28	27	26	26	26	26	25	25	24	24	23	23
(C) Water Sales (x1000 m3)	10,151	10,859	11,530	12,282	12,874	13,611	14,388	15,093	15,834	16,462	17,013	17,644	18,268	18,790	19,378
(D) No. of Connections	18,700	19,750	20,810	21,860	22,950	23,900	25,050	25,970	26,770	27,440	28,000	28,550	29,090	29,610	30,110
(E) Average Water Tariff (Baht/m3)	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11
1. Operating Revenue:															
1.1 Water Sales	72,171	77,206	81,981	86,756	91,531	96,773	102,301	107,509	112,578	117,041	120,960	125,450	129,887	133,598	137,777
1.2 Connection Fees	5,340	6,030	6,087	6,030	6,259	5,455	6,604	5,283	4,594	3,847	3,216	3,158	3,101	2,986	2,032
1.3 Service Charges	2,404	2,539	2,676	2,811	2,951	3,073	3,221	3,339	3,442	3,528	3,600	3,671	3,740	3,807	3,871
1.4 Other Revenue	366	393	416	438	461	482	514	531	553	570	585	606	626	643	658
Total 1.	80,282	86,168	91,159	96,034	101,202	105,784	112,639	116,463	121,166	124,987	128,361	132,885	137,355	141,035	144,338
2. Expenses:															
2.1 Operation & Maintenance															
- Personnel Cost	8,956	9,086	9,471	9,829	10,214	10,810	11,544	11,604	11,680	11,740	11,740	11,740	11,740	11,740	11,740
- Electricity & Fuel Cost	8,844	9,382	9,826	10,377	10,859	11,405	12,598	13,118	13,684	14,122	14,556	15,012	15,454	15,838	16,282
- Chemical Cost	2,246	2,361	2,469	2,573	2,682	2,808	2,957	3,084	3,222	3,326	3,422	3,521	3,619	3,706	3,798
- Connection Cost	2,350	2,291	2,313	2,291	2,379	2,073	2,509	2,008	1,746	1,462	1,222	1,200	1,178	1,135	1,091
- Raw Water Cost	3,095	3,446	3,752	3,489	3,811	4,176	4,628	2,073	2,482	2,789	3,081	3,358	3,665	3,927	4,190
- Other Cost	3,563	3,689	3,861	4,027	4,218	4,398	4,796	4,951	5,080	5,232	5,330	5,465	5,598	5,683	5,683
Sub-total 2.1	29,054	30,254	31,692	32,587	34,162	35,670	39,032	36,837	37,894	38,670	39,350	40,296	41,254	42,029	42,784
2.2 Share of Head & Regional Office Overhead Expenses	12,826	13,766	14,564	15,343	16,168	16,900	17,995	18,606	19,358	19,968	20,507	21,230	21,944	22,532	23,060
2.3 Debt Service	12,050	11,696	12,187	13,088	17,513	24,226	28,117	35,244	35,907	34,454	33,002	41,948	40,256	38,564	29,342
Total 2.	53,930	55,717	58,443	61,017	67,843	76,796	85,144	90,688	93,159	93,093	92,859	103,474	103,454	103,126	95,186
3. Net Cash Flow Surplus:															
3.1 Annual	26,352	30,451	32,716	35,017	33,360	28,988	27,495	25,775	28,007	31,894	35,502	29,411	33,981	37,909	49,152
3.2 Cumulative	26,352	56,802	89,519	124,535	157,895	186,883	214,378	240,152	268,160	300,054	335,556	364,967	398,868	436,777	485,929
4. Cost of Water after Debt Service (Baht/m3)*	4.78	4.60	4.56	4.52	4.77	5.16	5.37	5.54	5.47	5.30	5.14	5.54	5.36	5.20	4.69

Note: \* [(Total 2.) x ((1.1 Water Sales) / (Total 1.))] / (3. Water Sales m3)

Table-10.2 CASH FLOW PROJECTED (1,000 Baht) AT CURRENT PRICE. (CHIANGMAI WATERWORKS)

Description	Text Ref.	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
(A) Water Production (x1000 m3)		14,754	15,557	16,240	16,947	17,659	18,493	19,496	20,341	21,253	21,949	22,593	23,277	23,943	24,530	25,199
(B) Unaccounted for Water (x)		31	30	29	28	27	26	26	26	26	25	25	24	24	23	23
(C) Water Sales (x1000 m3)		10,151	10,859	11,530	12,202	12,874	13,611	14,388	15,093	15,834	16,462	17,013	17,644	18,268	18,790	19,378
(D) No. of Connections		18,700	19,750	20,810	21,860	22,950	23,900	25,050	25,970	26,770	27,440	28,000	28,550	29,090	29,610	30,110
(E) Average Water Tariff (Baht/m3)**		7.11	7.34	7.59	7.84	8.10	8.36	8.64	8.92	9.22	9.52	9.84	10.16	10.50	10.84	11.20
1. Operating Revenue:																
1.1 Water Sales		72,171	79,754	87,481	95,631	104,224	113,830	124,303	134,692	145,967	156,762	167,357	179,297	191,765	203,754	217,060
1.2 Connection Fees		5,340	6,229	6,495	6,646	7,127	6,417	8,024	6,631	5,936	5,153	4,449	4,514	4,378	4,554	4,523
1.3 Service Charges		2,404	2,623	2,855	3,098	3,360	3,615	3,914	4,191	4,443	4,725	4,981	5,246	5,522	5,806	6,099
1.4 Other Revenue		366	406	444	483	525	567	624	667	716	763	810	866	925	981	1,043
Total 1.		80,282	89,011	97,275	105,859	115,237	124,429	136,865	146,180	157,103	167,404	177,597	189,923	202,791	215,095	228,726
2. Expenses:																
2.1 Operation & Maintenance																
- Personnel Cost		8,956	9,722	10,843	12,041	13,388	15,162	17,324	18,633	20,068	21,584	23,094	24,711	26,441	28,292	30,272
- Electricity & Fuel Cost		8,844	9,691	10,485	11,439	12,365	13,415	15,307	16,465	17,743	18,914	20,139	21,455	22,816	24,155	25,651
- Chemical Cost		2,246	2,439	2,635	2,836	3,054	3,303	3,593	3,871	4,178	4,455	4,735	5,032	5,343	5,652	5,984
- Connection Cost		2,350	2,367	2,468	2,526	2,708	2,438	3,049	2,520	2,263	1,958	1,691	1,715	1,740	1,731	1,719
- Raw Water Cost		3,095	3,559	4,004	3,846	4,339	4,912	5,624	2,602	3,218	3,735	4,262	4,799	5,410	5,990	6,601
- Other Cost		3,563	3,811	4,120	4,439	4,803	5,173	5,827	6,214	6,587	7,008	7,374	7,811	8,265	8,667	8,953
Sub-total 2.1		29,054	31,589	34,555	37,127	40,658	44,403	50,725	50,306	54,057	57,653	61,295	65,524	70,015	74,487	79,180
2.2 Share of Head & Regional Office Overhead Expenses		12,826	14,221	15,541	16,912	18,410	19,879	21,866	23,334	25,099	26,745	28,373	30,342	32,398	34,364	36,542
2.3 Debt Service		12,050	11,696	12,187	13,088	17,513	24,226	28,117	35,244	35,907	34,454	33,002	41,948	40,256	38,564	29,342
Total 2.		53,930	57,506	62,283	67,127	76,581	88,508	100,707	108,904	115,063	118,852	122,670	137,814	142,669	147,415	145,064
3. Net Cash Flow Surplus:																
3.1 Annual		26,352	31,505	34,992	38,732	38,656	35,921	36,158	37,276	42,039	48,552	54,927	52,109	60,121	67,680	83,661
3.2 Cumulative		26,352	57,857	92,849	131,580	170,237	206,158	242,315	279,592	321,631	370,183	425,111	477,220	537,341	605,021	686,682
4. Unit Cost of Water after Debt Service (Baht/m3)*		4.78	4.75	4.86	4.97	5.38	5.95	6.36	6.65	6.75	6.76	6.79	7.37	7.39	7.43	7.10

Note: \* [(Total 2.) x ((1.1 Water Sales) / (Total 1.))] / (3. Water Sales m3)

\*\*Based upon the assumption that the water tariff increases every year at the rate of 3.5 %.

Table-10.3 CASH FLOW PROJECTED (1,000 Baht ) AT CURRENT PRICE. (CHIANGMAI WATERWORKS)

Description	Text Ref.	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
(A) Water Production (x1000 m3)		14,754	15,557	16,240	16,947	17,659	18,493	19,496	20,341	21,253	21,949	22,593	23,277	23,943	24,530	25,199
(B) Unaccounted for Water (%)		31	30	29	28	27	26	26	26	26	25	25	24	24	23	23
(C) Water Sales (x1000 m3)		10,151	10,859	11,530	12,202	12,874	13,611	14,388	15,093	15,854	16,462	17,013	17,644	18,268	18,790	19,378
(D) No. of Connections		18,760	19,750	20,810	21,860	22,950	23,900	25,050	25,970	26,770	27,440	28,000	28,550	29,090	29,610	30,110
(E) Average Water Tariff (Baht/m3)**		6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90
<b>1. Operating Revenue:</b>																
1.1 Water Sales		70,039	74,925	79,559	84,193	88,827	93,915	99,279	104,140	109,253	113,584	117,387	121,744	126,051	129,652	133,707
1.2 Connection Fees		5,340	6,030	6,087	6,030	6,259	5,455	6,604	5,283	4,594	3,847	3,216	3,158	3,101	2,986	2,871
1.3 Service Charges		2,404	2,539	2,676	2,811	2,951	3,073	3,221	3,339	3,442	3,528	3,600	3,671	3,740	3,807	3,871
1.4 Other Revenue		356	382	405	426	449	469	500	517	537	554	569	589	609	625	643
<b>Total 1.</b>		<b>78,141</b>	<b>83,877</b>	<b>88,727</b>	<b>93,460</b>	<b>98,487</b>	<b>102,912</b>	<b>109,604</b>	<b>113,279</b>	<b>117,826</b>	<b>121,514</b>	<b>124,772</b>	<b>129,162</b>	<b>133,501</b>	<b>137,071</b>	<b>141,093</b>
<b>2. Expenses:</b>																
2.1 Operation & Maintenance																
- Personnel Cost		8,956	9,722	10,843	12,041	13,368	15,162	17,324	18,633	20,068	21,584	23,094	24,711	26,441	28,292	30,272
- Electricity & Fuel Cost		8,844	9,691	10,485	11,439	12,365	13,415	15,307	16,465	17,743	18,914	20,139	21,455	22,816	24,155	25,651
- Chemical Cost		2,246	2,439	2,635	2,836	3,054	3,303	3,593	3,871	4,178	4,455	4,735	5,032	5,343	5,652	5,984
- Connection Cost		2,350	2,367	2,468	2,526	2,708	2,438	3,049	2,520	2,263	1,958	1,691	1,715	1,740	1,731	1,719
- Raw Water Cost		3,095	3,559	4,004	3,846	4,339	4,912	5,624	2,602	3,218	3,735	4,262	4,799	5,410	5,990	6,601
- Other Cost		3,563	3,811	4,120	4,439	4,803	5,173	5,827	6,214	6,587	7,008	7,374	7,811	8,265	8,667	8,953
<b>Sub-total 2.1</b>		<b>29,054</b>	<b>31,589</b>	<b>34,555</b>	<b>37,127</b>	<b>40,658</b>	<b>44,403</b>	<b>50,725</b>	<b>50,306</b>	<b>54,057</b>	<b>57,653</b>	<b>61,295</b>	<b>65,524</b>	<b>70,015</b>	<b>74,487</b>	<b>79,180</b>
2.2 Share of Head & Regional Office Overhead Expenses		12,483	13,399	14,174	14,930	15,733	16,440	17,509	18,096	18,822	19,411	19,932	20,633	21,326	21,897	22,539
<b>2.3 Debt Service</b>		<b>12,050</b>	<b>11,696</b>	<b>12,187</b>	<b>13,088</b>	<b>17,513</b>	<b>24,226</b>	<b>28,117</b>	<b>35,244</b>	<b>35,907</b>	<b>34,454</b>	<b>35,002</b>	<b>41,948</b>	<b>40,256</b>	<b>38,564</b>	<b>29,342</b>
<b>Total 2.</b>		<b>53,587</b>	<b>56,684</b>	<b>60,916</b>	<b>65,145</b>	<b>73,903</b>	<b>85,069</b>	<b>96,350</b>	<b>103,646</b>	<b>108,787</b>	<b>111,519</b>	<b>114,229</b>	<b>128,105</b>	<b>131,598</b>	<b>134,947</b>	<b>131,062</b>
<b>3. Net Cash Flow Surplus:</b>																
3.1 Annual		24,554	27,193	27,811	28,315	24,584	17,844	13,254	9,633	9,039	9,995	10,543	1,057	1,903	2,123	10,031
3.2 Cumulative		24,554	51,746	79,557	107,872	132,455	150,299	163,553	173,186	182,225	192,220	202,763	203,821	205,724	207,847	217,878
4. Unit Cost of Water after Debt Service (Baht/m3)*		4.73	4.66	4.74	4.81	5.18	5.70	6.07	6.31	6.37	6.33	6.32	6.84	6.80	6.79	6.41

Note: \* [(Total 2.) x ((1.1 Water Sales) / (Total 1.)) / (3. Water Sales m3)]

\*\* Based upon the assumption that the water tariff remains unchanged up to 2000.

Table-10.4 FORMULA SUGGESTED FOR SHARE ALLOCATION OF HEAD AND REGIONAL OFFICE EXPENSES BASED ON WATERWORKS NET SURPLUSES FOR 1985 (in Million Baht)

Item	Chiangmai Waterworks	Pattaya Waterworks	Ubon-Rat in Suphanburi Waterworks	Total Revenue of PWA	All Waterworks of PWA	Item	Head Office	Regional Office I	Regional Office II	Regional Office VIII	Regional Office IX
Revenue	64.614	49.106	27.999	7.556	1,307.990	Revenue of w/w under its jurisdiction	1,307.990	196.049	130.639	100.181	168.068
Expenses	21.627	8.205	11.039	4.960	641.685	Expense of office	159.273	6.959	8.102	5.545	8.001
Surplus (B)	42.987	40.901	16.960	2.596	666.305	Expens/Surplus of all waterworks under jurisdiction	0.239	0.010	0.012	0.008	0.012
Share Percentage (A)						=SHARE PERCENTAGE (A)					
Head Off Expenses	0.239	0.239	0.239	0.239							
Reg Off Expenses	0.012	0.010	0.008	0.012							
Total	0.251	0.249	0.247	0.251							
Share Amount (B)x(A)											
Head Off Expenses	10.276	9.777	4.054	0.621							
Reg Off Expenses	0.516	0.427	0.141	0.032							
Total	10.792	10.204	4.195	0.652							

Table-10.5 CASH FLOW PROJECTED ( x 1,000 Baht ) AT 1986 PRICE. (CHIANGMAI WATERWORKS)

Description	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
(A) Water Production (x1000 m3)	14,754	15,557	16,240	16,947	17,659	18,493	19,496	20,341	21,253	21,949	22,593	23,277	23,943	24,550	25,199
(B) Unaccounted for water (%)	31	30	29	28	27	26	26	26	26	25	25	24	24	23	23
(C) Water Sales (x1000 m3)	10,151	10,859	11,530	12,202	12,874	13,611	14,388	15,093	15,834	16,462	17,013	17,644	18,268	18,790	19,378
(D) No. of Connections	18,700	19,750	20,810	21,860	22,950	23,900	25,050	25,970	26,770	27,440	28,090	28,550	29,090	29,610	30,110
(E) Average Water Tariff (Baht/m3)	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11	7.11
<b>1. Operating Revenue:</b>															
1.1 Water Sales	72,171	77,206	81,981	86,756	91,531	96,773	102,301	107,309	112,578	117,041	120,960	125,450	129,887	133,598	137,777
1.2 Connection Fees	5,340	6,030	6,087	6,030	6,259	5,455	6,604	5,283	4,594	3,847	3,216	3,158	3,101	2,986	2,032
1.3 Service Charges	2,404	2,539	2,676	2,811	2,951	3,073	3,221	3,339	3,442	3,528	3,600	3,671	3,740	3,807	3,871
1.4 Other Revenue	366	393	416	438	461	482	514	531	553	570	585	606	626	643	658
<b>Total 1.</b>	<b>80,282</b>	<b>86,168</b>	<b>91,159</b>	<b>96,034</b>	<b>101,202</b>	<b>105,784</b>	<b>112,639</b>	<b>116,463</b>	<b>121,166</b>	<b>124,987</b>	<b>128,361</b>	<b>132,885</b>	<b>137,355</b>	<b>141,035</b>	<b>144,338</b>
<b>2. Expenses:</b>															
2.1 Operation & Maintenance															
- Personnel Cost	8,956	9,086	9,471	9,829	10,214	10,810	11,544	11,604	11,680	11,740	11,740	11,740	11,740	11,740	11,740
- Electricity & Fuel Cost	8,844	9,382	9,826	10,377	10,859	11,405	12,598	13,118	13,684	14,122	14,556	15,012	15,454	15,838	16,282
- Chemical Cost	2,246	2,361	2,469	2,573	2,682	2,808	2,957	3,084	3,222	3,326	3,422	3,521	3,619	3,706	3,798
- Connection Cost	2,350	2,291	2,313	2,291	2,379	2,073	2,509	2,008	1,746	1,462	1,222	1,200	1,178	1,135	1,091
- Raw Water Cost	3,095	3,446	3,752	3,489	3,811	4,176	4,628	2,073	2,482	2,789	3,081	3,358	3,665	3,927	4,190
- Other Cost	3,563	3,689	3,661	4,027	4,218	4,598	4,796	4,951	5,080	5,232	5,330	5,465	5,598	5,683	5,683
Sub-total 2.1	29,054	30,254	31,692	32,587	34,162	35,670	39,032	36,837	37,894	38,670	39,350	40,296	41,254	42,029	42,784
2.2 Share of Head & Regional Office Overhead Expenses **	13,409	14,392	15,225	16,040	16,903	17,668	18,813	19,452	20,237	20,875	21,439	22,194	22,941	23,556	24,107
<b>2.3 Debt Service</b>	<b>12,050</b>	<b>11,696</b>	<b>12,187</b>	<b>13,088</b>	<b>17,513</b>	<b>24,226</b>	<b>28,117</b>	<b>35,244</b>	<b>35,907</b>	<b>34,454</b>	<b>33,002</b>	<b>41,948</b>	<b>40,256</b>	<b>38,564</b>	<b>29,342</b>
<b>Total 2.</b>	<b>54,513</b>	<b>56,342</b>	<b>59,105</b>	<b>61,714</b>	<b>68,578</b>	<b>77,564</b>	<b>85,962</b>	<b>91,533</b>	<b>94,038</b>	<b>94,000</b>	<b>93,791</b>	<b>104,438</b>	<b>104,451</b>	<b>104,149</b>	<b>96,254</b>
<b>3. Net Cash Flow Surplus:</b>															
3.1 Annual	25,769	29,825	32,055	34,320	32,625	28,220	26,677	24,929	27,128	30,987	34,570	28,446	32,904	36,885	48,105
3.2 Cumulative	25,769	55,594	87,649	121,968	154,593	182,813	209,491	234,420	261,548	292,535	327,105	355,552	388,455	425,341	473,445
4. Unit Cost of Water after Debt Service (Baht/m3)	4.83	4.65	4.61	4.57	4.82	5.21	5.43	5.59	5.52	5.35	5.20	5.59	5.41	5.25	4.74

Note: \* [(Total 2.) x ((1.1 Water Sales) / (Total 1.))] / (3.Water Sales m3)  
 \*\* Calculated by a tentative new formula based on waterworks net surplus.

Table-10.6 CASH FLOW PROJECTED (1,000 Baht) AT CURRENT PRICE. (CHIANGMAI WATERWORKS)

Description	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
(A) Water Production (x1000 m <sup>3</sup> )	14,754	15,557	16,240	16,947	17,659	18,493	19,496	20,341	21,253	21,949	22,593	23,277	23,943	24,530	25,199
(B) Unaccounted for Water (%)	31	30	29	28	27	26	26	26	26	25	25	24	24	23	23
(C) Water Sales (x1000 m <sup>3</sup> )	10,151	10,859	11,530	12,202	12,874	13,611	14,388	15,093	15,834	16,462	17,013	17,644	18,268	18,790	19,378
(D) No. of Connections	18,700	19,750	20,810	21,860	22,950	23,900	25,050	25,970	26,770	27,440	28,000	28,550	29,090	29,610	30,110
(E) Average Water Tariff (Baht/m <sup>3</sup> )**	7.11	7.34	7.59	7.84	8.10	8.36	8.64	8.92	9.22	9.52	9.84	10.16	10.50	10.84	11.20
<b>1. Operating Revenue:</b>															
1.1 Water Sales	72,171	79,754	87,481	95,631	104,224	113,830	124,303	134,692	145,967	156,762	167,357	179,297	191,765	203,754	217,060
1.2 Connection Fees	5,340	6,229	6,495	6,646	7,127	6,417	8,024	6,631	5,956	5,153	4,449	4,514	4,578	4,554	4,523
1.3 Service Charges	2,404	2,623	2,855	3,098	3,360	3,615	3,914	4,191	4,463	4,725	4,981	5,246	5,522	5,806	6,099
1.4 Other Revenue	366	406	444	483	525	567	624	667	716	763	810	866	925	981	1,043
<b>Total 1.</b>	<b>80,282</b>	<b>89,011</b>	<b>97,275</b>	<b>105,859</b>	<b>115,237</b>	<b>124,429</b>	<b>136,865</b>	<b>146,180</b>	<b>157,103</b>	<b>167,404</b>	<b>177,597</b>	<b>189,923</b>	<b>202,791</b>	<b>215,095</b>	<b>228,726</b>
<b>2. Expenses:</b>															
2.1 Operation & Maintenance															
- Personnel Cost	8,956	9,722	10,843	12,041	13,368	15,162	17,324	18,633	20,068	21,584	23,094	24,711	26,441	28,292	30,272
- Electricity & Fuel Cost	8,844	9,691	10,485	11,439	12,365	13,415	15,307	16,465	17,743	18,914	20,139	21,455	22,816	24,155	25,651
- Chemical Cost	2,246	2,439	2,635	2,836	3,054	3,303	3,593	3,871	4,178	4,455	4,735	5,032	5,343	5,652	5,984
- Connection Cost	2,350	2,367	2,468	2,526	2,708	2,438	3,049	2,520	2,263	1,938	1,691	1,715	1,740	1,731	1,719
- Raw Water Cost	3,095	3,559	4,004	4,339	4,339	4,912	5,624	2,602	3,218	3,735	4,262	4,799	5,410	5,990	6,601
- Other Cost	5,563	3,811	4,120	4,439	4,803	5,173	5,827	6,214	6,587	7,008	7,374	7,811	8,265	8,667	8,953
Sub-total 2.1	29,054	31,589	34,555	37,127	40,658	44,403	50,725	50,306	54,057	57,653	61,295	65,524	70,015	74,487	79,180
2.2 Share of Head & Regional Office Overhead Expenses ***	12,678	14,057	15,362	16,717	18,198	19,650	21,614	23,085	24,810	26,437	28,046	29,993	32,025	33,968	36,120
<b>Total 2.</b>	<b>41,732</b>	<b>45,646</b>	<b>49,917</b>	<b>53,844</b>	<b>58,856</b>	<b>64,053</b>	<b>72,339</b>	<b>73,391</b>	<b>78,867</b>	<b>84,090</b>	<b>89,341</b>	<b>95,517</b>	<b>102,040</b>	<b>108,455</b>	<b>115,300</b>
<b>2.3 Debt Service</b>	<b>12,050</b>	<b>11,698</b>	<b>12,187</b>	<b>13,088</b>	<b>17,513</b>	<b>24,226</b>	<b>28,117</b>	<b>35,244</b>	<b>35,907</b>	<b>34,454</b>	<b>33,002</b>	<b>41,948</b>	<b>40,256</b>	<b>38,564</b>	<b>29,342</b>
<b>Total 2.</b>	<b>53,782</b>	<b>57,342</b>	<b>62,104</b>	<b>66,932</b>	<b>76,369</b>	<b>88,279</b>	<b>100,455</b>	<b>108,635</b>	<b>114,774</b>	<b>118,544</b>	<b>122,343</b>	<b>137,465</b>	<b>142,296</b>	<b>147,019</b>	<b>144,643</b>
<b>3. Net Cash Flow Surplus:</b>															
3.1 Annual	26,500	31,669	35,171	38,926	38,869	36,150	36,410	37,546	42,329	48,860	55,254	52,459	60,495	66,076	84,083
3.2 Cumulative	26,500	58,169	93,340	132,266	171,135	207,285	243,695	281,240	323,569	372,429	427,684	480,142	540,637	608,713	692,796
<b>4. Unit Cost of Water after Debt Service (Baht/m<sup>3</sup>)**</b>	<b>4.76</b>	<b>4.73</b>	<b>4.84</b>	<b>4.96</b>	<b>5.37</b>	<b>5.93</b>	<b>6.34</b>	<b>6.63</b>	<b>6.73</b>	<b>6.74</b>	<b>6.78</b>	<b>7.36</b>	<b>7.37</b>	<b>7.41</b>	<b>7.08</b>

Note: \* [(Total 2.) x ((1.1 Water Sales) / (Total 1.))] / (3. Water Sales m<sup>3</sup>)  
 \*\* Based upon the assumption that the water tariff increases every year at the rate of 3.3 %.  
 \*\*\* Calculated by a new tentative formula based on waterworks net surplus.



(CHIANGMAI WATERWORKS)

Table-10.7 CASH FLOW PROJECTED ( 1,000 Baht ) AT CURRENT PRICE.

Description	Text Ref.	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
(A) Water Production (x1000 m3)		14,754	15,557	16,240	16,947	17,659	18,493	19,496	20,341	21,253	21,949	22,593	23,277	23,943	24,530	25,199
(B) Unaccounted for Water (%)		31	30	29	28	27	26	26	26	26	25	25	24	24	23	23
(C) Water Sales (x1000 m3)		10,151	10,859	11,530	12,202	12,874	13,611	14,388	15,093	15,834	16,462	17,013	17,644	18,268	18,790	19,378
(D) No. of Connections		18,700	19,750	20,810	21,860	22,950	23,900	25,050	25,970	26,770	27,440	28,000	28,550	29,090	29,610	30,110
(E) Average Water Tariff (Baht/m3)**		7.11	7.11	7.11	7.84	7.84	7.84	8.64	8.64	8.64	9.52	9.52	9.52	10.50	10.50	10.50
<b>1. Operating Revenue:</b>																
1.1 Water Sales		72,171	77,206	81,981	95,631	100,895	106,673	124,303	130,389	136,790	156,762	162,011	168,024	191,765	197,244	203,413
1.2 Connection Fees		5,340	6,030	6,087	6,646	6,900	6,013	8,024	6,419	5,582	5,133	4,307	4,230	4,578	4,409	4,239
1.3 Service Charges		2,404	2,539	2,676	3,098	3,233	3,387	3,914	4,057	4,182	4,725	4,822	4,917	5,522	5,621	5,716
1.4 Other Revenue		366	393	416	483	509	532	624	645	671	763	784	812	925	949	977
Total 1.		80,282	86,168	91,159	105,859	111,556	116,606	136,865	141,511	147,225	167,404	171,924	177,983	202,791	208,223	214,345
<b>2. Expenses:</b>																
2.1 Operation & Maintenance		8,956	9,722	10,843	12,041	13,388	15,162	17,324	18,633	20,068	21,564	23,094	24,711	26,441	28,292	30,272
- Personnel Cost		8,844	9,691	10,485	11,439	12,365	13,415	15,307	16,465	17,743	18,914	20,139	21,455	22,816	24,155	25,651
- Electricity & Fuel Cost		2,246	2,367	2,635	2,836	3,054	3,303	3,593	3,871	4,178	4,455	4,735	5,032	5,343	5,652	5,984
- Chemical Cost		2,350	2,367	2,468	2,526	2,708	2,438	3,049	2,520	2,263	1,938	1,691	1,715	1,740	1,731	1,719
- Connection Cost		3,095	3,559	4,004	3,846	4,339	4,912	5,624	2,602	3,218	3,735	4,262	4,799	5,410	5,998	6,601
- Raw Water Cost		3,563	3,811	4,120	4,439	4,803	5,173	5,827	6,214	6,587	7,008	7,374	7,811	8,265	8,667	8,953
- Other Cost		29,054	31,589	34,555	37,127	40,658	44,403	50,725	50,306	54,057	57,653	61,295	65,524	70,015	74,487	79,180
Sub-total 2.1		12,678	13,608	14,396	16,717	17,617	18,414	21,614	22,347	23,250	26,437	27,150	28,107	32,025	32,883	33,849
2.2 Share of Head & Regional Office Overhead Expenses ***		12,050	11,696	12,187	13,088	17,513	24,226	28,117	35,244	35,907	34,454	33,002	41,948	40,256	38,564	29,342
2.3 Debt Service		53,782	56,893	61,138	66,932	75,787	87,043	100,455	107,897	113,214	118,544	121,447	135,579	142,296	145,934	142,372
Total 2.		26,500	29,275	30,021	38,926	35,769	29,562	36,410	33,613	34,011	48,860	50,477	42,404	60,495	62,290	71,973
3. Net Cash Flow Surplus:		26,500	55,774	85,795	124,722	160,490	190,053	226,463	260,076	294,087	342,947	393,424	435,828	496,323	558,612	630,586
3.1 Annual		4.76	4.69	4.77	4.96	5.32	5.85	6.34	6.59	6.64	6.74	6.73	7.25	7.37	7.36	6.97
3.2 Cumulative																
4. Unit Cost of Water after Debt Service (Baht/m3)*																

Note: \* [(Total 2.) x ((1.1 Water Sales) / (Total 1.))] / (3. Water Sales m3)

\*\* Based upon the assumption that the water tariff increases every three years at the rate of 3.3 % per annum.

\*\*\* Calculated by a new tentative formula based on waterworks net surplus.

Table-10.8 CASH FLOW PROJECTED (1,000 Baht ) AT CURRENT PRICE. (CHIANGMAI WATERWORKS)

Description	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
(A) Water Production (x1000 m3)	14,754	15,557	16,240	16,947	17,659	18,493	19,496	20,341	21,253	21,949	22,593	23,277	23,943	24,530	25,199
(B) Unaccounted for Water (%)	31	30	29	28	27	26	26	26	26	25	25	24	24	23	23
(C) Water Sales (x1000 m3)	10,151	10,859	11,530	12,202	12,874	13,611	14,388	15,093	15,834	16,462	17,013	17,644	18,268	18,790	19,378
(D) No. of Connections	18,700	19,750	20,810	21,860	22,950	23,900	25,050	25,970	26,770	27,440	28,000	28,550	29,090	29,610	30,110
(E) Average Water Tariff (Baht/m3)**	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90	6.90
1. Operating Revenue:															
1.1 Water Sales	70,039	74,925	79,559	84,193	88,827	93,915	99,279	104,140	109,253	113,584	117,387	121,744	126,051	129,652	133,707
1.2 Connection Fees	5,340	6,030	6,087	6,030	6,259	5,455	6,604	5,283	4,594	3,847	3,216	3,158	3,101	2,986	2,871
1.3 Service Charges	2,404	2,539	2,676	2,811	2,951	3,073	3,221	3,339	3,442	3,528	3,600	3,671	3,740	3,807	3,871
1.4 Other Revenue	356	382	405	426	449	469	500	517	537	554	569	589	609	625	643
Total 1.	78,141	83,877	88,727	93,460	98,487	102,912	109,604	113,279	117,826	121,514	124,772	129,162	133,501	137,071	141,093
2. Expenses:															
2.1 Operation & Maintenance															
- Personnel Cost	8,956	9,722	10,843	12,041	13,388	15,162	17,324	18,633	20,068	21,584	23,094	24,711	26,441	28,292	30,272
- Electricity & Fuel Cost	8,844	9,691	10,485	11,439	12,365	13,415	15,307	16,465	17,743	18,914	20,139	21,455	22,816	24,155	25,651
- Chemical Cost	2,246	2,439	2,635	2,836	3,054	3,303	3,593	3,871	4,178	4,455	4,735	5,032	5,343	5,652	5,984
- Connection Cost	2,350	2,367	2,468	2,526	2,708	2,438	3,049	2,520	2,263	1,958	1,691	1,715	1,740	1,731	1,719
- Raw Water Cost	3,095	3,559	4,004	3,846	4,359	4,912	5,624	2,602	3,218	3,735	4,262	4,799	5,410	5,990	6,601
- Other Cost	3,563	3,811	4,120	4,439	4,803	5,173	5,827	6,214	6,587	7,008	7,374	7,811	8,265	8,667	8,953
Sub-total 2.1	29,054	31,589	34,555	37,127	40,658	44,403	50,725	50,306	54,057	57,653	61,295	65,524	70,015	74,487	79,180
2.2 Share of Head & Regional Office Overhead Expenses ***	12,340	13,246	14,012	14,759	15,553	16,252	17,309	17,889	18,607	19,189	19,704	20,397	21,082	21,646	22,281
2.3 Debt Service	12,050	11,696	12,187	13,088	17,513	24,226	28,117	35,244	35,907	34,454	33,082	41,948	40,256	38,564	29,342
Total 2.	53,444	56,531	60,754	64,974	73,723	84,881	96,150	103,439	108,571	111,297	114,001	127,869	131,354	134,697	130,804
3. Net Cash Flow Surplus:															
3.1 Annual	24,696	27,346	27,973	28,486	24,763	18,032	13,454	9,840	9,254	10,217	10,771	1,293	2,147	2,373	10,289
3.2 Cumulative	24,696	52,042	80,015	108,500	133,264	151,295	164,749	174,589	183,843	194,060	204,832	206,125	208,272	210,645	220,934
4. Unit Cost of Water after Debt Service (Baht/m3)*	4.72	4.65	4.72	4.80	5.17	5.69	6.05	6.30	6.36	6.32	6.30	6.83	6.79	6.78	6.40

Note: \* [(Total 2.) x ((1.1 Water Sales) / (Total 1.))] / (3. Water Sales m3)

\*\* Based upon the assumption that the water tariff remains unchanged up to 2000.

\*\*\* Calculated by a new tentative formula based on waterworks net surplus.

ICHANGMAI WATERWORKS

Table-10.9 DEBT SERVICE PROJECTED

Year	FOREIGN CURRENCY PORTION (in 1,000 Baht)				LOCAL CURRENCY PORTION (in 1,000 Baht)				Debt Service	TOTAL DEBT SERVICE				
	Rehabili. and Modifi.	Stage 1 Expansion	Loans Outstanding	Interest Payments	Rehabili. and Modifi.	Stage 1 Expansion	Loans Outstanding	Interest Payments						
			Beginning	Ending			Beginning	Ending	1st year	Later year	Principal Repayment	Principal Repayment	Sub-total	Sub-total
1987	3,233		0	3,233	137	0	0	0	808	0	0	0	14	11,739
1988	16,166		3,233	21,399	772	275	0	0	5,349	28	0	0	108	12,510
1989	15,391		21,399	36,790	654	1,819	0	0	9,197	187	0	0	255	13,852
1990		83,639	36,790	120,429	3,555	3,127	0	0	28,793	322	1,314	0	2,002	19,576
1991		127,199	120,429	247,628	5,406	10,256	0	0	59,279	557	1,314	0	2,878	29,182
1992			247,628	247,628	0	21,048	0	0	57,965	0	1,314	0	3,389	34,867
1993			247,628	247,628	0	21,048	0	0	49,122	0	1,314	7,530	10,873	42,119
1994			247,628	245,584	0	21,048	2,044	0	40,278	0	1,314	7,530	10,565	43,622
1995			245,584	245,540	0	20,875	2,044	0	31,434	0	1,314	7,530	10,254	42,907
1996			243,540	241,496	0	20,701	2,044	0	22,590	0	1,314	7,530	9,944	42,192
1997			241,496	227,739	0	20,527	2,044	11,713	15,060	791	0	7,530	8,321	51,877
1998			227,739	213,982	0	19,358	2,044	11,713	7,530	527	0	7,530	8,057	50,212
1999			213,982	200,225	0	18,188	2,044	11,713	0	264	0	7,530	7,794	48,548
2000			200,225	186,468	0	17,019	2,044	11,713	0	0	0	7,530	39,354	29,607
2001			186,468	172,711	0	15,850	2,044	11,713	0	0	0	7,530	28,438	27,268
2002			172,711	158,954	0	14,680	2,044	11,713	0	0	0	7,530	26,099	24,929
2003			158,954	145,197	0	13,511	2,044	11,713	0	0	0	7,530	23,591	21,421
2004			145,197	131,439	0	12,342	2,044	11,713	0	0	0	7,530	20,252	20,252
2005			131,439	117,682	0	11,172	2,044	11,713	0	0	0	7,530	19,083	19,083
2006			117,682	103,925	0	10,003	2,044	11,713	0	0	0	7,530	17,913	17,913
2007			103,925	90,168	0	8,834	2,044	11,713	0	0	0	7,530	16,700	16,700
2008			90,168	76,411	0	7,664	2,044	11,713	0	0	0	7,530	15,504	15,504
2009			76,411	62,654	0	6,495	2,044	11,713	0	0	0	7,530	14,309	14,309
2010			62,654	48,897	0	5,326	2,044	11,713	0	0	0	7,530	13,104	13,104
2011			48,897	35,140	0	4,156	2,044	11,713	0	0	0	7,530	12,000	12,000
2012			35,140	23,426	0	2,987	0	11,713	0	0	0	7,530	11,000	11,000
2013			23,426	11,713	0	1,991	0	11,713	0	0	0	7,530	10,000	10,000
2014			11,713	0	0	996	0	11,713	0	0	0	7,530	9,000	9,000

Note: \* Based upon the assumption that the foreign currency portion is financed by a foreign financial institution whose lending rate is 8.5 % per annum.

Table-10.10 CASH FLOW PROJECTED ( x 1,000 Baht ) AT CURRENT PRICE. (CHIANGMAI WATERWORKS)

Description	Text Ref.	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
(A) Water Production (x1000 m <sup>3</sup> )		14,754	15,557	16,240	16,947	17,659	18,493	19,496	20,341	21,253	21,949	22,593	23,277	23,943	24,530	25,199
(B) Unaccounted for Water (C)		31	30	29	28	27	26	26	26	26	25	25	24	24	23	23
(C) Water Sales (x1000 m <sup>3</sup> )		10,151	10,859	11,530	12,202	12,874	13,611	14,388	15,093	15,804	16,462	17,013	17,644	18,268	18,790	19,378
(D) No. of Connections		18,700	19,750	20,810	21,860	22,950	23,900	24,950	25,970	26,770	27,440	28,000	28,550	29,090	29,610	30,110
(E) Average Water Tariff (Baht/m <sup>3</sup> )**		7.11	7.11	7.11	7.84	7.84	7.84	8.64	8.64	8.64	9.52	9.52	9.52	10.50	10.50	10.50
1. Operating Revenue:																
1.1 Water Sales		72,171	77,206	81,981	95,631	100,895	106,673	124,303	130,389	136,790	156,762	162,011	168,024	191,765	197,244	203,413
1.2 Connection Fees		5,340	6,030	6,067	6,646	6,900	6,013	8,024	6,419	5,582	5,153	4,307	4,230	4,578	4,409	4,233
1.3 Service Charges		2,404	2,539	2,676	3,098	3,253	3,387	3,914	4,057	4,182	4,725	4,822	4,917	5,522	5,621	5,716
1.4 Other Revenue		366	393	416	483	509	532	624	645	671	763	784	812	925	949	977
Total 1.		80,282	86,188	91,159	105,859	111,556	116,606	136,865	141,511	147,225	167,404	171,924	177,983	202,791	208,223	214,345
2. Expenses:																
2.1 Operation & Maintenance																
- Personnel Cost		8,956	9,722	10,843	12,041	13,388	15,162	17,324	18,633	20,068	21,584	23,094	24,711	26,441	28,292	30,272
- Electricity & Fuel Cost		8,844	9,691	10,485	11,439	12,365	13,415	15,307	16,465	17,743	18,914	20,193	21,455	22,816	24,155	25,651
- Chemical Cost		2,246	2,433	2,635	2,836	3,054	3,303	3,593	3,871	4,178	4,455	4,735	5,032	5,343	5,652	5,984
- Connection Cost		2,350	2,367	2,468	2,526	2,708	2,438	3,049	2,520	2,263	1,958	1,691	1,715	1,740	1,731	1,719
- Raw Water Cost		3,095	3,559	4,004	3,846	4,339	4,912	5,624	2,602	3,218	3,735	4,262	4,799	5,410	5,990	6,601
- Other Cost		3,563	3,811	4,120	4,439	4,803	5,173	5,827	6,214	6,587	7,008	7,374	7,811	8,265	8,667	8,953
Sub-total 2.1		29,054	31,589	34,555	37,127	40,658	44,403	50,725	50,306	54,057	57,653	61,295	65,524	70,015	74,467	79,180
2.2 Share of Head & Regional Office Overhead Expenses		10,953	11,717	12,442	13,167	13,891	14,687	15,526	16,286	17,086	17,763	18,358	19,039	19,713	20,276	20,910
2.3 Debt Service ***		12,050	11,739	12,510	13,852	19,576	29,182	34,867	42,119	43,622	42,907	42,192	51,877	50,212	48,548	39,354
Total 2.		52,057	55,045	59,508	64,145	74,125	88,271	101,117	108,711	114,765	118,323	121,845	136,440	139,940	143,310	139,444
3. Net Cash Flow Surplus:																
3.1 Annual		28,225	31,123	31,651	41,713	37,431	28,334	35,748	32,800	32,461	49,061	50,079	41,543	52,850	64,313	74,902
3.2 Cumulative		28,225	59,347	90,999	132,712	170,143	198,477	234,225	267,024	299,485	348,566	398,645	440,188	503,038	567,951	642,853
4. Unit Cost of Water after Debt Service (Baht/m <sup>3</sup> )		4.61	4.54	4.64	4.75	5.21	5.93	6.38	6.64	6.73	6.73	6.75	7.30	7.24	7.22	6.83

Note: \* [(Total 2.) x (C.I. Water Sales) / (Total 1.)] / (C. Water Sales m<sup>3</sup>)

\*\* Based upon the assumption that the water tariff increases every 3 years at the rate of 3.3 % per annum.

\*\*\* Based upon the assumption that the foreign currency portion is financed by a foreign financial institution whose lending rate is 8.5 % per annum.

Table-10.11 FIXED ASSETS, UNIT COST AFTER DEPRECIATION AND RATE OF RETURN

[CHIANGMAI WATERWORKS] x 1,000 BAHT

ITEM	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
<b>Fixed Assets</b>														
Accumulative Fixed Assets	201,300	207,943	218,888	248,673	276,001	379,757	549,729	567,870	586,609	605,968	625,955	646,621	667,960	690,003
Less Accumulative Depreciation	92,536	102,521	113,199	125,224	138,556	155,787	179,252	204,096	230,385	258,187	287,573	318,617	351,396	385,992
Net Fixed Assets in Operation	108,764	105,422	109,672	146,062	156,567	318,618	527,917	363,773	356,224	347,781	338,392	328,005	316,564	304,010
Work in Progress	4,033	26,646	41,735	113,770	252,088	157,440	0	0	0	0	0	0	0	0
<b>TOTAL</b>	112,797	132,068	151,407	259,832	408,655	476,058	527,917	363,773	356,224	347,781	338,392	328,005	316,564	304,010
Total Cost before Depreciation and Interest**	45,646	49,917	53,844	58,856	64,053	72,338	73,390	78,867	84,090	89,342	95,517	102,040	108,454	115,301
Total Cost after Depreciation but before Interest	59,902	64,522	64,522	70,881	77,385	89,569	96,856	103,711	110,379	117,143	124,962	133,084	141,234	149,897
Total Cost After Depreciation and Interest	60,734	66,486	66,486	76,187	89,636	105,942	113,058	118,764	124,210	129,753	136,291	143,012	149,702	156,905
Unit Cost of Water (Baht/cm <sup>3</sup> ) after depreciation and Interest*	5.27	5.45	5.45	5.92	6.59	7.36	7.49	7.50	7.55	7.63	7.72	7.83	7.97	8.10
Average Rate Base	107,093	107,547	107,547	127,867	151,314	237,592	423,267	445,845	359,999	352,002	343,086	333,198	322,284	310,287
Surplus after Depreciation and Interest	36,541	39,373	39,373	39,050	34,793	30,922	33,122	38,339	43,194	47,844	53,632	59,778	65,992	71,821
Rate of Return after Completion of Construction						13%	8%	8%	12%	14%	16%	18%	20%	23%

Note: \*  $\frac{\text{Total Cost after Depreciation and Debt Service of this Table} \times (1.1 \text{ Water Sales})}{\text{Cash Flow Table}} \div (1.1 \text{ Operating Revenue})$  of Cash Flow Table

\*\* Includes Share of Head & Regional Office Overhead Expenses calculated by a new tentative formula based on waterworks net surplus.

Table-10.12 FINANCIAL INTERNAL RATE OF RETURN (FIRR)

(CHIANGMAI WATERWORKS) x 1,000 BAHT

YEAR	TOTAL REVENUE	CAPITAL INVESTMENT COST	OPERATING COSTS & H. R. O. *	1986 PRICE : NET REVENUE :	NET BENEFITS	
					DISCOUNTED AT 10%	DISCOUNTED AT 11%
1987	0	3,912	0	-3,912	-3,556	-3,524
1988	0	9,179	0	-9,179	-7,586	-7,450
1989	15,752	17,453	6,164	-7,865	-5,909	-5,751
1990	20,920	91,816	8,602	-79,498	-54,298	-52,368
1991	25,502	135,174	10,875	-120,547	-74,850	-71,539
1992	32,357		15,382	16,975	9,582	9,075
1993	36,181		13,826	22,355	11,471	10,767
1994	40,884		15,668	25,216	11,763	10,942
1995	44,705		17,083	27,622	11,714	10,798
1996	48,079		18,326	29,753	11,471	10,478
1997	52,603		20,027	32,575	11,417	10,336
1998	57,073		21,732	35,341	11,261	10,102
1999	60,753		23,122	37,630	10,900	9,690
2000	64,056		24,429	39,628	10,435	9,193
2001	64,056		24,429	39,628	9,487	8,282
2002	64,056		24,429	39,628	8,624	7,462
2003	64,056		24,429	39,628	7,840	6,722
2004	64,056		24,429	39,628	7,127	6,056
2005	64,056		24,429	39,628	6,479	5,456
2006	64,056		24,429	39,628	5,890	4,915
Salvage		-123,103		123,103	18,299	2,720
TOTALS	883,203	134,431	341,807	406,965	17,563	-7,635

Note: \* Share Allocation of Head and Regional  
Office Overhead Expenses calculated by  
a new tentative formula based on waterworks surplus.

$$\text{FIRR} = 10 + (11 - 10) \times 17,563 / (17,563 + 7,635) \\ = 10.697\%$$