KINGDOM OF THAILAND
WATER SUPPLY PROJECT
IN
NAKHON RAJASIMA
FEASIBILITY REPORT

—SEPTEMBER 1971—

PREPARED FOR

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

BY

THE JAPANESE SURVEY TEAM

FOR

PROVINCIAL WATER SUPPIY IN

THAILAND

KINGDOM OF THAILAND

THE EXPANSION PLAN

THE WATER WORKS

IN

NAKHON RAJASIMA

AUGUST 1971

PREPARED FOR

OVERSEAS TECHNICAL COOPERATION AGENCY

GOVERNMENT OF JAPAN

BY

THE JAPANESE SURVEY TEAM

FOR

PROVINCIAL WATER WORKS IN THAILAND

JICA LIBRARY
1017992[7]

P R E F A C E

In response to a request of the Government of Thailand, the Government of Japan agreed to cooperate in the implementation of investigations for an expansion project in connection with water supply to Chiang Mai and Korat in Thailand, and entrusted the Overseas Technical Cooperation Agency (OTCA) to undertake the said work.

In view of the great importance of the project, OTCA organized and sent to Thailand a survey team composed of four members headed by Dr. Tamon Ishibashi, Prof., University of Tokyo for a period of thirty days on and from March 8, 1971. Upon their return to Tokyo, the team prepared a basic expansion plan for the project based upon data and information collected during their field studies, with the kind assistance of Dr. S. Naito, Colombo Plan expert and his colleagues who are serving with the Government of Thailand as Colombo Plan experts.

This report deals with the results of the investigations. It is my sincere hope that the report will be of great help in expediting the project, thereby contributing to promotion of the rapport between These two countries.

Finally, on behalf of OTCA, I would like to take this opportunity to express my deepest gratitude for the hospitality and kind collaboration extended by Thai government officials and people who assisted the team in conducting their field studies. I also wish to present my heartfelt thanks to officials of the Japanese Embassy in Bangkok and of the Ministry of Health and Welfare in Tokyo as well as leading personnel of Tokyo Engineering Consultant Co., Ltd. for their cooperation and assistance.

September 1971

Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

Letter of Transmittal

September 1971

Mr. Keiichi Tatsuke
Director General
Overseas Technical Cooperation Agency

Dear Sir:

Submitted herewith is a report on "Provincial Water Works in Thailand," The survey team stayed in Thailand from March 8 to April 7, 1971 and conducted field investigations for water supply program for Chiang Mai and Korat. Upon completion of the field works, the team submitted to the Government of Thailand a tentative report for its reference in the middle of August, 1971.

Upon their return to Tokyo, the team prepared a draft report and the three members of the team visited Thailand to explain its contents,

Agreement was reached between the team and the Government of Thailand at the meetings in connection with guidelines for the preparation of a final report. In accordance with this agreement, the team prepared this final report required for the said expansion program (target year: 2000) for water supply to Chiang Mai and Korat.

Plans have been drawn up for three consecutive stages of expansion of water facilities in order to demand for water in 1980, 1990 and 2000, respectively. Financial plans and rehabilitation programs are included in these plans.

I wish to take this opportunity to extend my deepest gratitude to Thai and Japanese personnel including the staff of the Provincial Municipality Water Works Division in Thailand, the Embassy of Japan, the Japanese Government Ministry of Foreign Affairs, the Ministry of Health and Welfare, the Overseas Technical Cooperation Agency and Tokyo Engineering Consultant Company Ltd. who assisted the team in conducting the investigations.

Respectfully yours,

Tamon Ishibashi
Chief, The Japanese Survey Team for
Provincial Water Works in Thailand

Organization of the Survey Team

Chief:	Tamon Ishibashi,	Professor of the Faculty of Technology, Tokyo University.
Members:	Sunao Kameda	Tokyo Engineering Consultant Co., Ltd.
	Hajime Yamada	Ditto
	Eiichi Mutsuro	Overseas Technical Cooperation Agency

Members commissioned on the spot:

Dr. Sachiho Naito
Colombo Plan Expert

Mr. Susumu Sakaguchi
Colombo Plan Expert

Mr. Koichi Degawa
Colombo Plan Expert

Mr. Kenji Sugi
Colombo Plan Expert

Mr. Masaharu Takasugi
Personal Assistant

Mr. Susumu Adachi
Personal Assistant

The Schedule of the Survey

Date	Activities
March 8 (Mon) 1971	Left Tokyo for Bangkok
9 (Tue)	Visited the Japanese Embassy
10 (Wed)	Visited P.M.W.D. for a previous arrangement
11 (Thu)	- Ditto -
12 (Fri)	Left Bangkok for Chiang Mai
13 (Sat)	Field Survey in Chiang Mai
14 (Sun)	- Ditto -
15 (Mon)	- Ditto -
16 (Tue)	Left Chiang Mai for Bangkok
17 (Wed)	Left Bangkok for Korat
18 (Thu)	Field Survey in Korat
19 (Fri)	- Ditto -
20 (Sat)	Left Korat for Bangkok

Date	Activities
March 21 (Sun) 1971	Arrange the result of the survey
22 (Mon)	- ditto -
23 (Tue)	Arrange the data for the Meeting
24 (Wed)	1st Meeting with P.M.W.D.
25 (Thu)	Arrangement of the data
26 (Fri)	- ditto -
	Dr. Ishibashi reached Bangkok
27 (Sat)	Report on the Survey to the leader of the Team
28 (Sun)	Leader visited Chiang Mai; Mr. Kameda left BKK
29 (Mon)	Surveying in Chiang Mai
30 (Tue)	Left Chiang Mai for BKK
31 (Wed)	Arrangement of the data
April 1 (Thu)	Arrangement of the data
2 (Fri)	Leader left BKK for Korat
3 (Sat)	Surveying in Korat, Left Korat for BKK
4 (Sun)	Arrangement of the data for the 2nd Meeting
5 (Mon)	2nd Meeting
6 (Tue)	Final Arrangement
7 (Wed)	Mr. Yamad and Mr. Mutsuro left BKK
8 (Thu)	Leader visited Embassy of Japan for greetings.
9 (Fri)	Leader left BKK

The Survey Team owed much to the cooperation of the following persons in Thailand.

Embassy of Japan

Mr. Hiroaki Tamamitsu

Overseas Technical Cooperation Agency

Mr. Moriya Miyamoto

Mr. Akira Takahashi

Mr. Damrong Cholvijarn Director General	Department of Public andMunicipal Works Ministry of Interior Bangkok Thailand
Mr. Sakoljit Panomvan Chief Engineer	Ditto
Mr. Kasien Anambutr Director	Ditto
Mr. Sawasri Orvichian Design Chief	Ditto
Mr. Wiroon Rungrongthanin	Ditto
Mr. Banhan Mekvichai	Mayor of Korat City
Mr. Chana Thanthasiri	Superintendent of Korat Water Supply Division

CONTENTS

Page

Page

1. General Considerations

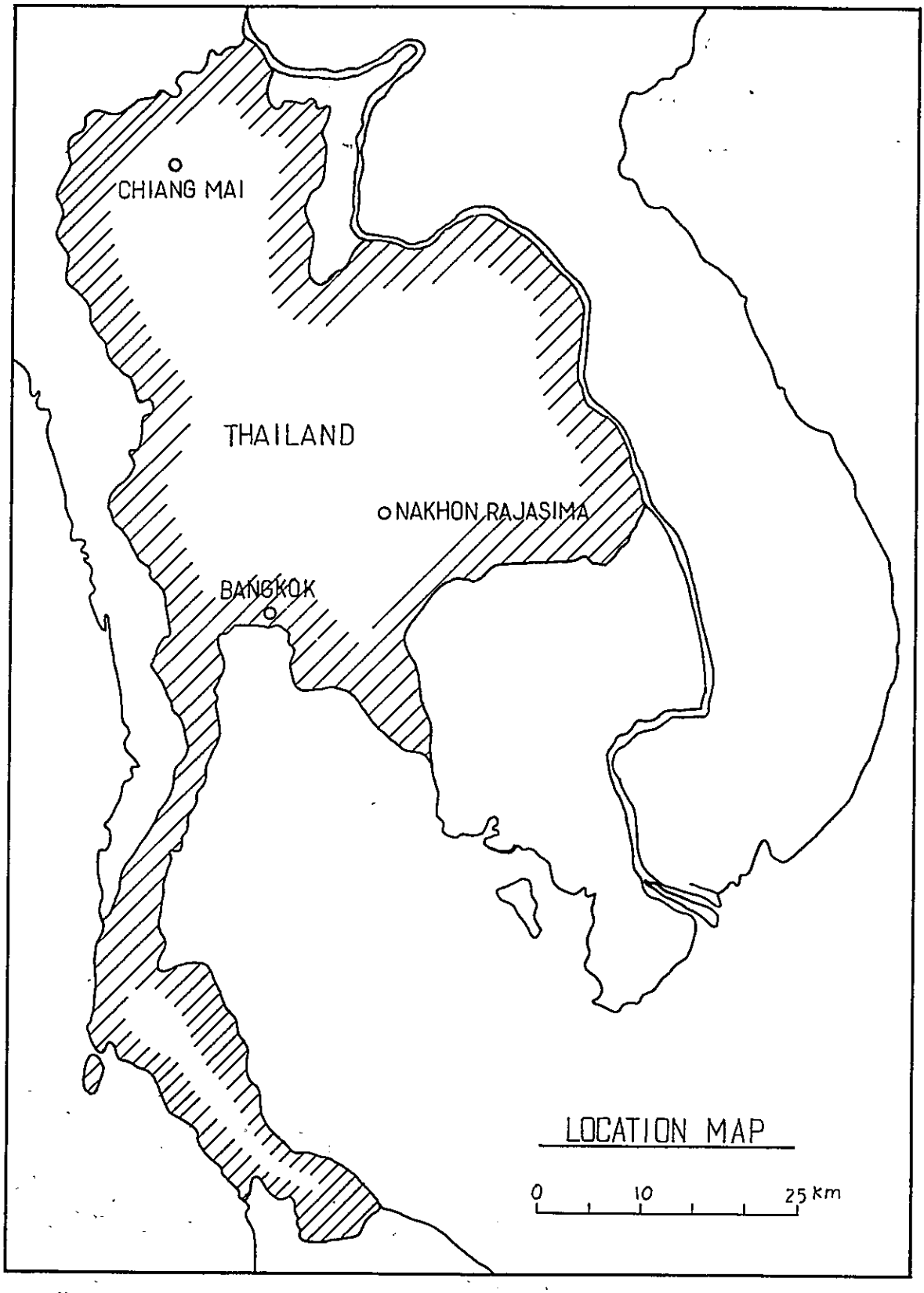
Nakhon Rajasima is located at the entrance of the Korat Plateau at a distance about 300 kilometers from Bangkok City along the highway constructed under the Friendship Plan. The muuicipality lies along a stretch of hills, formed of partly exposed limestone, while many pastures may be seen in the Plateau.

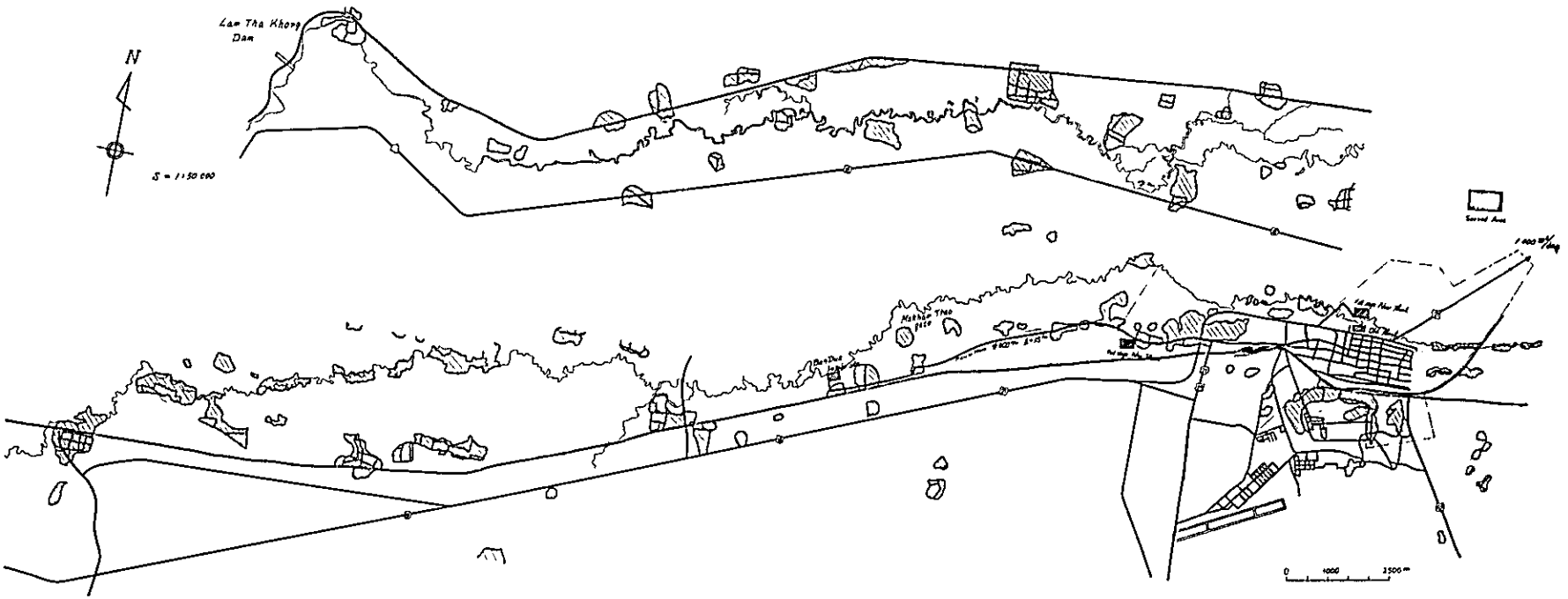
In this region, there exists much rock salt, and crystal is found even at 350 ft. depth. The Mine Bureau reports that salt is present in the waters of both deep wells and shallow wells. Accordıng to Japanese survey team's water testing data on the local shallow wells, located at the Buddhist temple near Makamtham Gate, the conductance meter ındicated 24 x 100 /cm, and the well's waters tasted salty. The water supply source for the military facilities is underground water, from 8 deep wells 8 inches in diameter, 80 meters deep, and with a capacity of 800 m^3/day per well. Considering all factors involved, the Lam Tha Kong Irrigation river was sslected as the most desirable sourrce.

Statistics on the city water works water supply for 1970 reveal the following information. The total quantity of water supplied through the distribution mains was 400,000 m^3per month and the equivalent income from water charges was 300,000 Baht per month. As the water charge is 1.5 Baht/m^3, the quantity of water measured was 200,000 m^3/month.

Water leakage from the pipelines and unmeasured water account for this discrepancy. The percentage of unmeasured water increased to high figure as an aftermath of past periods when water was restricted. Measures to correct this situation are desirable.

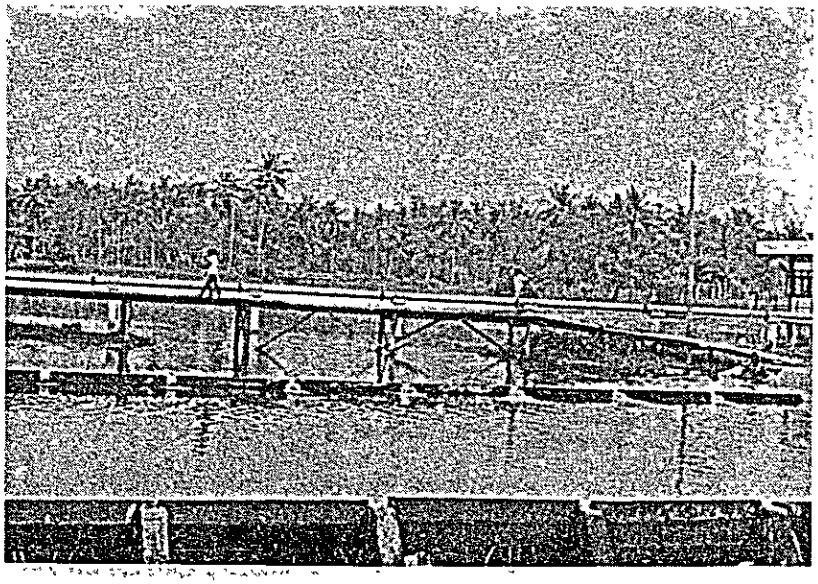
There are 6,800 registered families in the municıpal area, the average family consisting of 10 persons. In order to supply potable water to the Cho-Ho district to a branch main off the city water distribution main is planned to be laid, and included in the design of the Cho-Ho Water Works system. This is to be an undertaking of the Cho-Ho Water Works, and is not included in the Nakhon Rajasima Project.


CHIANG MAI
THAILAND
NAKHON RAJASIMA
BANGKOK
LOCATION MAP
0
10
25 km


Lam Tha Khong
Dam
N
S = 1/50 000

2. Water Source Site -- Present Status and Tentative Proposal

(Existing Intake Site)



2-1 Present Condition of the Water Source

One of the major problems of the existing water intake located on the Lam Tha Kong River is heavy water pollution caused by organic contamination. This is obvious from the large amount of scum found in the sedimentation tanks, and rapid sand filters. The accumulated sludge becomes septic so that much organic scum forms as foam. Thus, the existing water intake probably should be replaced in the near future, unless the water pollution can be eliminated by special counter measures.

Another problem is the permanent shortage of water. When the Japanese Survey Team visited the area on 19th March, there was sufficient water in the Lam Tha Kong River, the flow near the existing water intake being about 0.5 m^3/sec, which is more than the present water demand of about 0.2 m^3/sec.

However, this flow is not sufficient for future water demands, estimated at nearly 0.8 m^3/sec by 2000 A.D.

2-2 Tentative Proposals

The proposed water intake shall be located at Ban Dua along the Lam Tha Kong River, because this location seems to be best from technical and economical considerations.

There is still doubt about the river flow near Ban Dua. Although desk plans project an expected flow of about 7 to 17 m^3/sec near Ban Dua, assuming the maximum discharge to be 23 m^3/sec from the reservoir, the actual minimum flow may be less than 1 m^3/sec during the dry or non-irrigation season. The Japanese Survey Team measured the flow at Ban Dua at 0.7 m^3/sec on 18th March, 1971.

on the other hand, as mentioned above, a flow of about 0.5 m^3/sec was reported near the existing water intake. This means that, although there is some water usage from the Lam Tha Kong River between Ban Dua and the existing water intake, the volume used is not large during the

nonirrigation period. It is also necessary to point out that the above-mentioned flow statistic of 0.7 m^3/sec was obtained when the current discharge from the Lam Tha Kong Reservoir was about 6 m^3/sec. In other words, if the discharge from Lam Tha Kong Reservoir were to increase, a flow might be obtained greater than 0.7 m^3/sec at Ban Dua. This matter should be given further attention together with the Irrigation Department.

The above data indicates the proposed water supply extension project should be designed with the water intake of Ban Dua, which is the spot nearest to the Friendship Highway. An intake should be built somewhere near Ban Dua, designed adequate to supply estimated water demands for 1980 AD. A pump well should be constructed adjacent to the intake. A raw water main should be laid along the road between the intake pump well and the receiving well at the purification plant, of sufficient capacity to satisfy water demand in 1980 AD. The receiving well should be located near the Proposed No. 3 Water Treatment Plant from where raw water might be transferred to the new No. 2 Water Treatment Plant and the old existing No. 1 Water Treatment Plant.

It seems unlikely that existing facilities at No. 1 and No. 2 Water Treatment Plants can be used to the full extent of their design capaciiies. Therefore, No. 1 Water Treatment Plant and No. 2 water treatment plant with a calculated capacity of 23,440 m^3/day should be rated at 21,000 m^3/day.

It is also important, in event the Ban Dua water source is chosen, that the existing water distributing system be improved as soon as possible to reduce leakage and unmeasured water. Also, the pattern of population growth should be carefully surveyed, with attention to such factors as changes in military requirements.

2-3 Other Considerations

2-3-1 Lam Tha Kong River Conservancy

The existing Lam Tha Kong River shall be improved as soon as possible in order to maintain the necessary supply of water at all times and places. This conservancy project should be planned with careful consideration to not only municipal but also irrigation. Providing there is a 7 to 17 m^3/day river flow as predicted by desk plans, there will be no problem in obtaining sufficient water from Ban Dua, even in 2000 AD..

2-3-2 Makamthawn Gate Water Source

This gate was built in 1955, located 10 Km upstream from the existing water treatment plants, for the purpose of flow control of the irrigation canal, and it is being operated to supply raw water to the existing water treatment plant. There are several reservoir ponds upstream from this gate. Also, there are about 60,000 m^2 of municipal land on the right bank just upstream of this gate, which might be used for additional reservoir ponds.

If the Irrigation Department were to concur in pumping this water accumulated upstream above the gate, it would appear to be much easier than taking water from Ban Dua. Moreover, the length of the raw water main from the gate to the existing water treatment plant would be only 10 Km, while the distance from Ban Dua is 15 Km.

But, there is a difficulty to be considered to decide water source in Makamthawn Gate. That is, this gate was constructed for the purpose to control the irrigation canal. If there is a possibility to draw water from Makam Thawn Gate, it will refer to the negotiation with Irrigation Department.

2-4 Water Qualtiy

The survey team made tests, using a conductance meter, a p^H meter, and simple instruments for water testing by specific color. Water was sampled and brought to Japan for laboratory testing of factors which could not be tested in the field. The team acquired data on minimum flow during the dry season but did not acquire data on maximum turbidity, because the survey was made during the dry season in March and April.

Test results are as follows:

Place of Sampling: Ban Dua Irrigation Canal

Date	: 18th March 1971
Time	: A.M. 10:45
Temperature	: 32°C
Water Temperature	: 25°C
Conductivity	: 3.2×10^2 /cm
Turbidity	: 330 ppm
pH-Value	: 8.2

Place of Sampling: Makamthawn Canal Gate

Date	: 19th March 1971
Time	: P.M. 5:00
Temperature	: 29°C
Water Temperature	: 25°C
Conductivity	: 3.6×10^2 /cm
Turbidity	: 300 ppm
pH-Value	: 8.0
Ammonia Nitrogen	: 0.05 ppm, less than
Chlorine	: 25 ppm, less than
Potassium Permanganate Consumed	: 10-30 ppm
Total Hardness	: 110
Color	: 9°

3. Summary

3-1 Target Year

The growth of the population of this municipality is remarkable in comparison with other ordinal local municipalities. This is mainly because of the extension of the military camps, so an estimation of future growth based on recent growth rates is perhaps unreasonable. At the same time, if the armed forces should decrease, growth of all areas would be greatly and adversely affected.

Therefore, it is difficult to plan on a long-term basis. Consequently, the target year has been set at 1980 A. D. (Stage 1).

3-2 Water Intake Site

Waters in the lower reaches of the stream, where water is now being drawn, are much polluted. Scum is even found floating within the sedimentation basin. Therefore, the water source site should be located in the upper reaches of the stream, in the neighbourhood of the Makamthawn Gate or at Ban Dua.

It would be difficult to obtain adequate quantities of water if the intake were located at the Makamthawn Gate, about 10 kms. upstream from the existing water treatment plant. The quantity of water in the river is inadequate during the irrigation period.

Location of the water intake at Ban Dua, about 15 kms upstream from the existing water treatment plant, will assure an adequate supply of water, although construction costs will be higher than for Makam thawn.

During the first stage, sufficient supply of raw water presents no problems. Improvement of the river is necessary to provide an adequate supply for the 2nd stage of the long term plan.

Another alternative plan would be to establish a water intake at the Lam Tha Khong Dam, using a raw water pump and 64.5 kilometers of pipelines to send water to the existing water treatment plant. This plan is not practicable, because of the excessive investment cost of the

long pipeline compared to water demands (36,300 m^3/day) for the 1st stage, and because of the desirability of avoiding excessive investment till the future impact of troop requirements becomes more predictable.

Considering both the assurance of an adequate water intake and construction costs, it is recommended that the water intake facilities be built at Ban Dua.

3-3 Improvement of Business Efficiency

At present, there are large quantities of unmeasured or leaked water. The efficiency ratio is low. The price of water, now 1.5 baht/m^3, will have to be raised as future expansion of the works takes place.

The efficiency ratio should be 70% by 1977. This is necessary for a rational system of water charges.

4. The Existing Water Treatment Plant

The Existing Water Treatment Plant:

1. Filters:

	Size (m)	Capacity (m^3/hr)	Capacity (m^3/day)	Effective Capacity(m^3/day)
F No. 1	1.6 x 2.5 x 2	20	480	
F No. 2	3.0 x 3.0 x 2	40	960	
F No. 3	D-4.0 x 2	80	1,920	1,920
F No. 4	2.6 x 3.6 x 2	57	1,360	1,360
F No. 5	3.0 x 4.0 x 2	80	1,920	1,920
F No. 6	7.0 x 2.5 x 4	200	4,800	2,400
F No. 7	4.0 x 3.0 x 10	500	12,000	12,000
Total		977	23,440 =	21,000

Note: 2 basins for spare from No. 6 Filter

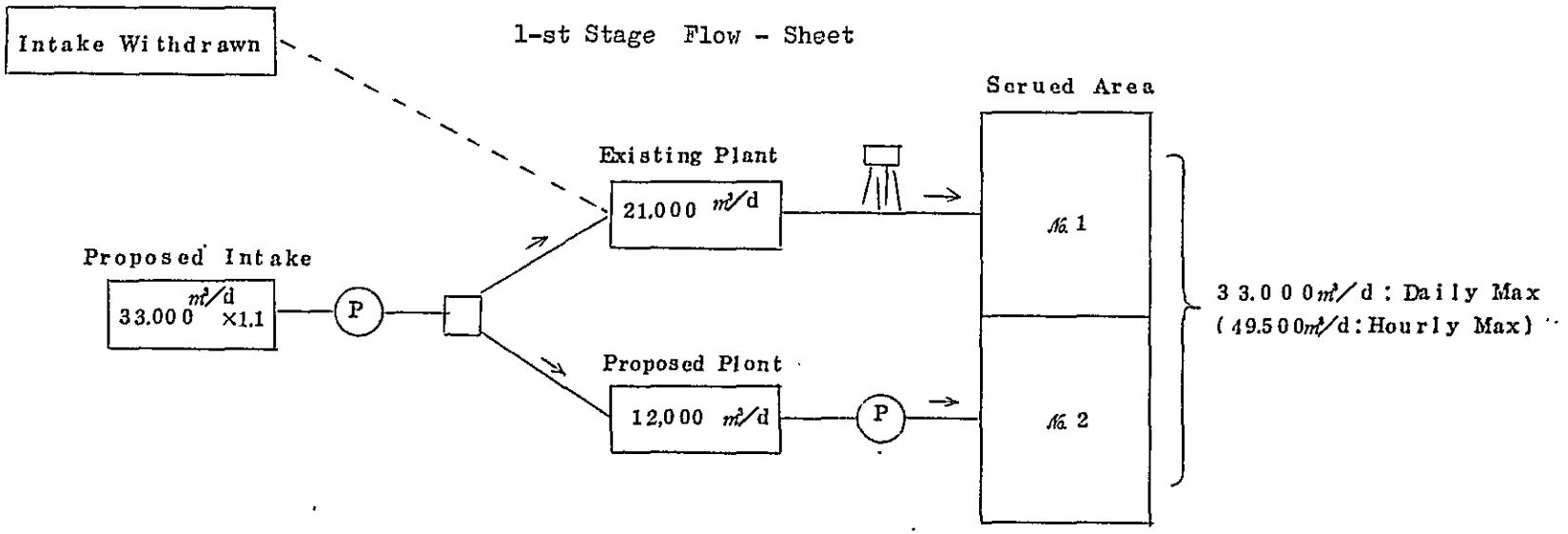
2. Clear Wells and Elevated Tanks:

Item	No.	Capacity (m^3)
ET.	No. 1	90
CW.	No. 1	500
CW.	No. 2	200
CW.	No. 3	200
CW.	No. 4	200
ET.	No. 2	250
CW.	No. 5	3,000
Total		4,440

5. Water Supply Expansion Plan

Nakhon Rajasima Project

		Basic Quantity				Proposed Plan		Construction Estimate		Alternate Estimate	
Stage	Year	Population	Water Demand	Existing	Balance	Water Intake	Water -Treatment	Cost	Remark	Cost	Remark
			m^3/d	m^3/d	m^3/d	m^3/d	m^3/d	(1,000 Baht)			
1-st Stage	1980	186,000	31,000	21,000	10,000	12,000x1.1	12,000	88,800	Ban Dua	—	—
2-nd Stage	1990	243,000	48,000	21,000	27,000	36,000x1.1	12,000x3 =36,000	64,800	Ban Dua	—	—
3-rd Stage	2000	301,000	69,000	21,000	48,000	48,000x1.1	12,000x4 =48,000	16,200	Ban Dua plus River Improvement	255,200	Lam Tha Kong Dam: excluding Water treatment & Distribution



5. Water Supply Expansion Plan

5-1 Served

Served areas are shown on the next page.

5-2 Planned Population and Quantity to be Supplied

In Nakon Rajasima, there occurred an unusual rate of population increase of about 10% in 1964, in 1965 and in 1966 because of military bases,and an increase of 4% per year has been maintained since. This increase is larger than the former average increase of 3% per year for Thailand. This means that the increased demand for water in Nakhon Rajasima is caused by social factors rather than by natural population increase, so it is needed to consider this phenomena when estimating future population on the basis of past statistics.

Estimated population for A.D. 1980 and A.D. 2000 is shown below by an arithmetical series method, a geometrical series method, and a power function method.

Table 5-2-1 Estimated Population

Method of Estimation / Year	$Y = ax + b$ $Y=2,490 \times +47,123$	$Pn= Po(1+r)$ $r= 0.05$	$Pn = Po + An^a$ $Pn=73,91 +3,284 \times n^{1.1194}$
1980	74,513	135,306	115,700
1990	99,413	220,762	151,000
2000	124,313	359,233	187,700

Moreover, the population in the area to be supplied will be augmented by unregistered persons and persons in outlying areas/

All three methods of calculating future population to be supplied employ the rate of birth multiplied with the present estimated population.

Should changes in defence arrangements so necessitate, new revised water demand curves may be desirable, especially for planning after 1980.

The planned daily maximum demand is set as 150% x (daily mean demand) and the planned hourly maximum demand is set as 150% x (daily max. demand) /24 hrs.

Table 5-2-2 Population Data for 11 Years from 1959 to 1969.

Year	Population	Year	Population
1959	42,718	1965	60,620 △
1960	44,630	1966	66,774 △
1961	46,601	1967	73,030
1962	48,984	1968	76,223
1963	52,064	1969	79,126
1964	55,210 △		

Note : indicates eccentrio increase

Power Function Method : $Pn = Po + An^a$

Table 5-2-3 Population Estimates Using the Power Function Method

$(Pn = Po + An^a)$

Year	Population	n	X=log n	X^2	Pn	Pn-Po	Y=log(Pn-Po)	XY
1958	40,806	0	____	___	73.91	___	_____	___
59	42,718	1	0	0	77.37	3.46	0.53908	0
60	44,630	2	0.30103	0.09062	80.84	6.93	0.84073	0.2538
61	46,601	3	0.47712	0.22764	84.41	10,50	1.02119	0.48723
62	48.984	4	0.60206	0.36248	88.72	14.81	1.17056	0.70475
63	52.064	5	0.69897	0.48856	94.30	20.39	1.30942	0.91525
64	55,210	6	0.77815	0.60552	100.00	26.09	1.41647	1.10223
$\sum$	____		2.85733	1.77482	_____	____	6.20745	3.46254

$$a = \frac{N\,XY - X\,Y}{N\,X^2 - X\,X} = \frac{6x3.46254 - 2.85733x6.29745}{6x1.77482 - 2.85733x2.85733} = 1.1194$$

$$b = \frac{X^2\,XY - X\,XY}{N\,X^2 - X\,X} = \frac{1.77482 \times 6.29745 - 2.85733 \times 3.46254}{6x1.77482 - 2.85733 \times 2.85733} = 0.51647$$

$$\log A = b = 0.51647 \qquad A = 3.284$$

$$Pn = 73.91 + 3.284 \times n^{1.1194}$$

Municipal Area

Year	Pn	Pn'	Population
1964	100	—	———
1968	117.17	—	———
1969	122.01	100	79,126
1970	126.91	104	82,290
1980	178.41	146.23	115,700
1990	232.86	190.85	151,000
2000	289.42	237.21	187,700

Municipal Area

The 1968 Unregistered population is estimated at 20,000 persons or nearly 26% of the registered population

Year	Registered Population	Unregistered Population	Approximate Total population
1968	76,223	20,000	96,000
1969	79,126	20,854	99,980 = 100,000
1970	82,290	21,662	103,952 = 104,000
1980	115,700	30,454	146,154 = 146,000
1990	151,000	39,748	190,748 = 191,000
2000	187,700	49,402	237,102 = 237,000

Suburban Area

Year	Coef.	Population	
1968	100	25,991	26,000
1969	104.27	27,101	27,000
1970	108.31	28,151	28,000
1980	152.27	39,576	40,000
1990	198.74	51,655	52,000
2000	247.01	64,200	64,000

Summary

Year	Population		Total Population in Water Served Area
	Suburban Area	Municipal Area	
1969	27,000	100,000	127,000
1970	28,000	104,000	132,000
1980	40,000	146,000	186,000
1990	52,000	191,000	243,000
2000	64,000	237,000	301,000

Water Demand

Water Consumption Coefficient by Years.

Year	Served Coef. (%)	Supply Unit (l/head/day)	Supply Coef. (m^3/head)
1970	60	225	0.1350
1980	65	250	0.1625
1990	70	275	0.1925
2000	75	300	0.2250

Water Demand for Served Area

Year	Demand for Served Area (m^3/day)	Cho-Ho Area (m^3/day)	Total Demand for Served Area (m^3/day)	Demand (m^3/hr)	Demand (m^3/sec)
1970	18,000	1,000	19,000	792	0.220
1980	30,000	1,000	31,000	1,292	0.359
1990	47,000	1,000	48,000	2,000	0.556
2000	68,000	1,000	69,000	2,875	0.799

FIG-5-2-2 POPULATION GROWTH CURVE

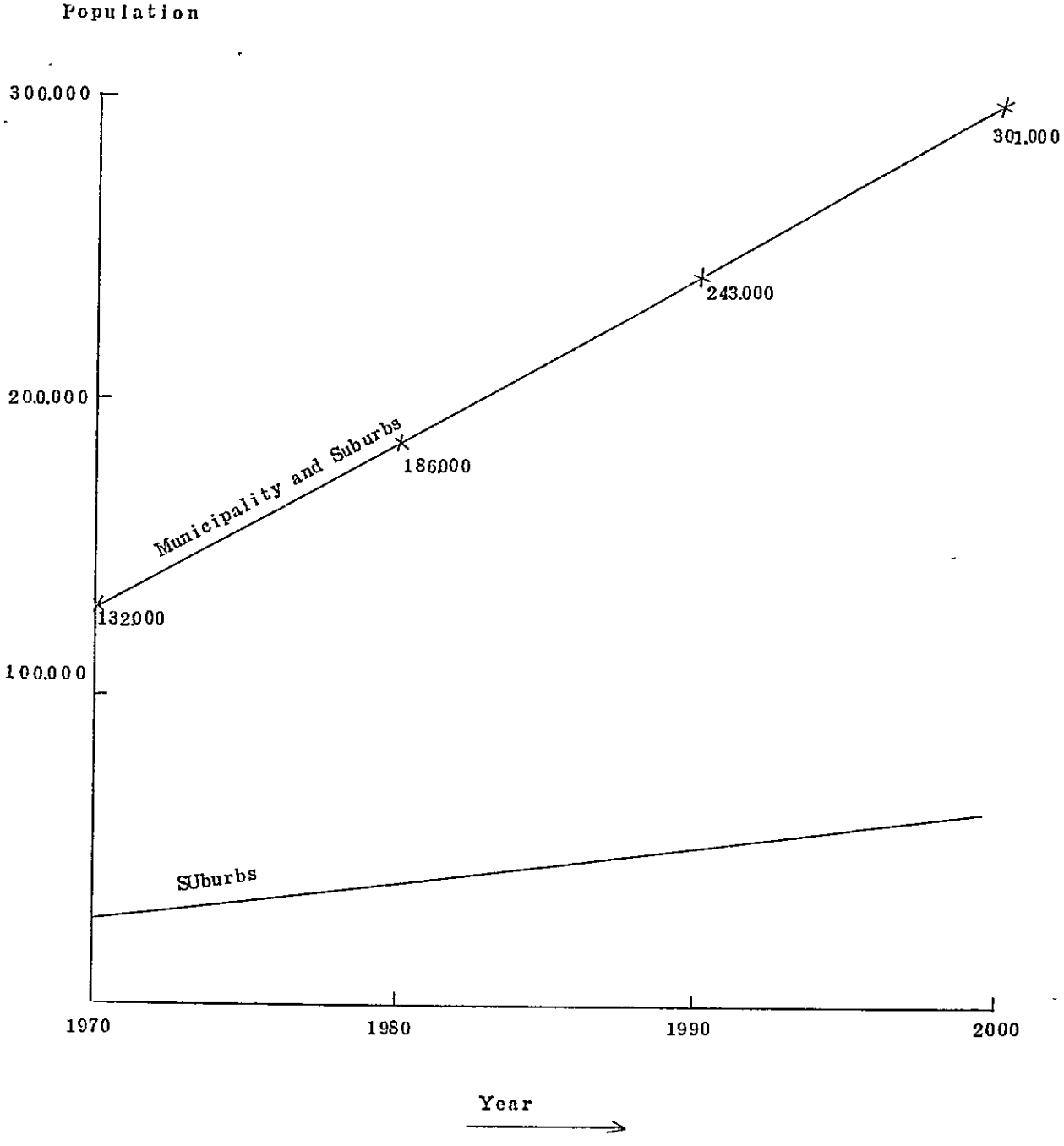
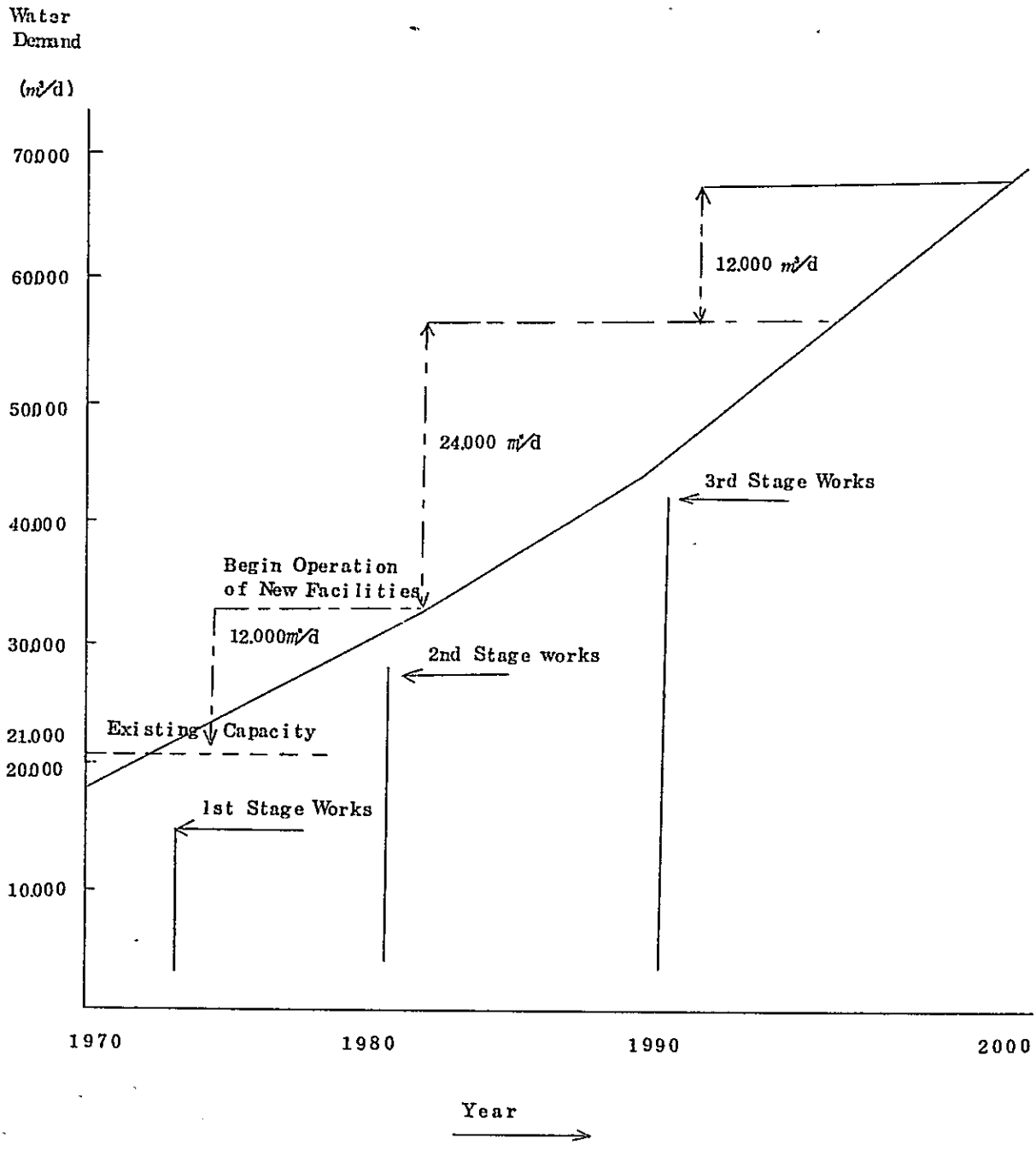


FIG -5-3 CONSTRUCTION PROGRAM



NAKHON RAJASIMA WATER SUPPLY EXPANSION PLAN

T-1 Estimated Water Demand

Year	Average Daily Demand (m^3/d)	Maximum Daily Demand (m^3/d)	Existing Plant Capacity (m^3/d)	Proposed Plant Capacity (m^3/d)
1970	12,700	19,000	22,560	———
1980	20,700	31,000	21,000	+ 12,000
1990	32,000	48,000	21,000	12,000 + 24,000
2000	46,000	69,000	21,000	36,000 + 12,000

T-2 Expansion Plan

Year	Raw Water (m^3/d)	Water Treatment (m^3/d)	Distribution System: Pumping Station (m^3/d)	Pumping Equipment (m^3/d)	Pipe Line Net works (m^3/d)
1970					
1980	(21,000+12,000)x1.1	12,000	12,000 x 1.5	12,000 x 1.5	12,000 x 1.5
1990	69,000 x 1.1	24,000	24,000 x 1.5	24,000 x 1.5	24,000 x 1.5
2000		12,000	12,000 x 1.5	12,000 x 1.5	12,000 x 1.5

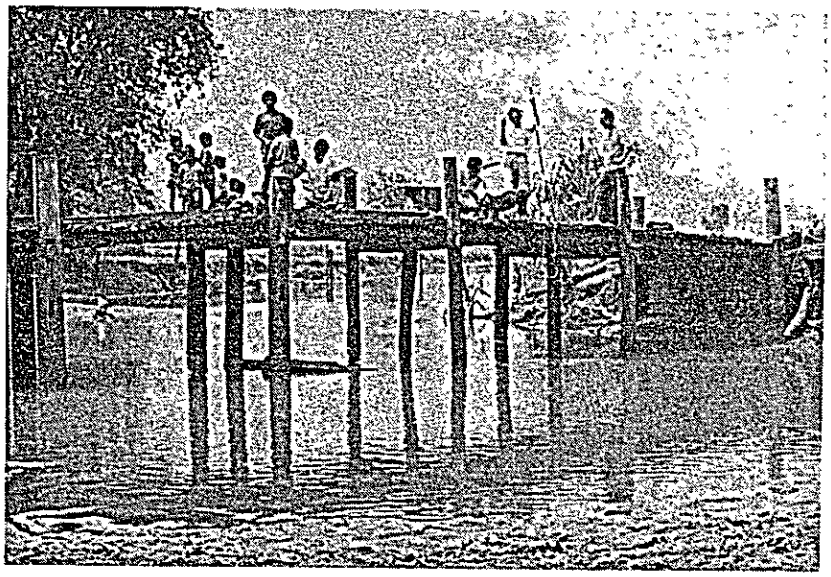
6. Water Intake Site

6-1 Location of Water Intake Site

Location of Intake: Ban Dua on the Lam Tha Kong River

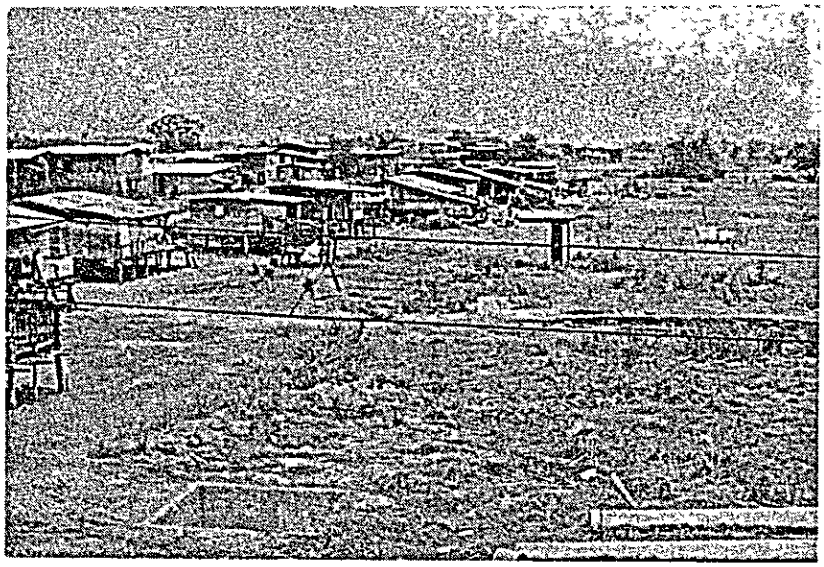
It is possible to intake 0.36 m^3/sec of raw water at Ban Dua on the Lam Tha Kong River, meeting requirements till 1980. Tests showed a flow of 0.7 m^3/sec during the height of the dry season. At the spillway upstream a flow of 6.0 m^3/sec was recorded. The proposed to meet requirements up to 1980 is planned to be located near the old plant, but since the old water source has been polluted, it is determind that raw water will be provided from Ban Dua.

(Proposed Intake Site)



7. Water Treatment Plant

(Proposed Construction Site)



7. Water Treatment Plant

7-1 Outline

Maximum daily demand in 1980 is estimated at 31,000 m^3/day. 21,000 m^3/day is planned to be supplied from the existing plant. Assuming demand to be 69,000 m^3/day in 2000 AD. or an increase from 1971 of 48,000 m^3/day. the proposed water treatment plant has been planned in 4 series the capacity of each series being 12,000 m^3/day. Therefore, the capacity of the proposed to be completed by 1980 has been set at 12,000 m^3/day.

But, capacities of the raw water mains have been designed surficient to supply not only the new plant (proposed to meet demands of Stage 1 up to 1980), but also the existing plant. The reason for this, as already mentioned, is that the raw water source of the existing plant is heavily polluted by organic contamination.

Table 7-1

Facility	1st Stage (1973-1980)
Expected Amount of Water Treated	12,000 m^3/day
Raw Water Demand	13,200 m^3/day (Proposed Plant) 23,100 m^3/day (Existing Plant)
Location of Proposed Plant	Adjacent to the existing plant
Conduit Main	Dia. 600 mm l=15 km.
Distributing System	Elevated Tank -- to send water from the old existing plant to the old city's served area Distributing Pump -- to send water from the old existing plant to the new served area

Table 7-1 (Con't)

Facility	1st Stage (1973-1980)
Intake Channel	1 : 2.0^{m}(W) x 1.5^{m}(D) x 5^{m}(L).
Suction well	1 : 6.0^{m}(W) x 3.0^{m}(D) X 5.0 (L)
Raw Water Main	Dia : 600 mm, l = 15 km
Raw Water Pump	3 : 12.6 m^{3}/min x 71^{m}
Receiving Well	1 : Dia. 5.0^{m} x Height 7.0^{m}
Mixing Basin	1 : 2.4^{m}(W) x 2.4^{m}(L) x 2.7^{m}(H)
Floculation Basin	2 : 8.0^{m}(W) x 12.0^{m}(L) x 3.0^{m}(H)
Sedimentation Basin	2: 8.0^{m}(W) x 31.5^{m}(L) x 3.0^{m}(H)
Rapid Sand Filter	4 : 6.4^{m}(W) x 6.4^{m}(L)
Elevated Tank	1 : 7.5^{m}(W) x 7.5^{m}(L) x 3.6^{m}(H)
Reservoir	1 : 40.0^{m}(W) x 25.0^{m}(L) x 3.0^{m}(H)
Distributing Pump	3 : 7.2 m^{3}/min
Distribution Pipe	Dia. 600 mm l= 150^{m}(MDCIP)
Distribution Pipe	500 1,810 (MDCIP)
Distribution Pipe	450 490 (MDCIP)
Distribution Pipe	400 2,250 (MDCIP)
Distribution Pipe	350 1,010 (MDCIP)
Distribution Pipe	300 1,160 (ACP)
Distribution Pipe	250 8,930 (ACP)
Distribution Pipe	200 11,840 (ACP)
Distribution Pipe	150 14,060 (ACP)
Distribution Pipe	100 11,730 (ACP)

7-2 Intake Facilities and Raw Water Mains

7-2-1 Planned Quantity of Raw Water Required from Water Sources.

The water is to be lifted from the pump well to a receiving well 15 kms distant. The pipes shall be ductile cast iron pipe. Air relief valves and drain valves shall be installed as necessary. The total head for the intake pump is planned to be about 71m.

7-2-2 Intake Channel: 1

Structure:	Reinforced Concrete
Dimension:	2.0m (W) x 1.5m (D) x 5.0m (L)
Velocity:	0.58 m/sec.

7-2-3 Raw Water Main

A single pipe line, 600mm in diameter and 15 kilometers in length, shall be laid as early as possible in Stage 1, from Ban Dua on the Lam Tha Kong River to the projected new plant to be built near the existing plant.

7-2-4 Raw Water Pump

Total Wuantity:	Q = 25.2 m^3/min
Number:	3 (including 1 spare)
Capacity:	12.6 m^3/min
Total Head:	71m
Motor:	3
Motive Power:	220 kw D = 300 x 200 mm
Type:	Double Suction Volute Pumps

7-2-5 Diesel Engine

Type:	Water-Cooled 4-cycle in-line 8-cylinder

Continuous output:	310
Speed:	1,800 rpm
Cooling System:	Radiator type
Starter:	Battery
Number:	3 (including 1 spare)

7-3 Treatment Plant

The treatment plant will consist of a receiving well, chemical dosing equipment, mixing basin, flocculation basin, horizontal flow sedimentation basin, rapid sand filter, elevated tank, sludge removal equipment, sludge basin, sterilizing equipment and necessary accessories.

Design of the plant will provide for a horizontal flow sedimentation basin and a surface washing apparatus for the filter. The advantage of a horizontal flow sedimentation basin is that it is stable to operate. A combination of surface and back wash is recommended for the design of the filter washing apparatus. The procedure for surface washing system will be as follows: Preceding the back wash, water will be discharged at high pressures to the surface of the filter layer utilizing numerous nozzles located above the filter, thus breaking up the mud layer and effectively washing it away. The scouring action of the sand grains also will help to prevent the formation of mudballs.

7-3-1 The Planned Capacity of Water Treatment

Total	33,000 m^3/d	
	21,000 m^3/d	..... Existing Plant
	12,000 m^3/d	..... Plant Planned for 1980

7-3-2 Receiving Well: 1

The receiving well shall be located in the entrance of the proposed plant. Water flow is brought under control here so that the water is stabilized. A measuring weir is provided so that the water may be accurately divided into 2 parts, namely that required for the proposed 1980 plant and that for the existing plant.

Structure: Reinforced concrete

Dimension: Dia. 5.0m x Height 7.0m

Capacity: 137 m^3

Retention Time: 5.4 min.

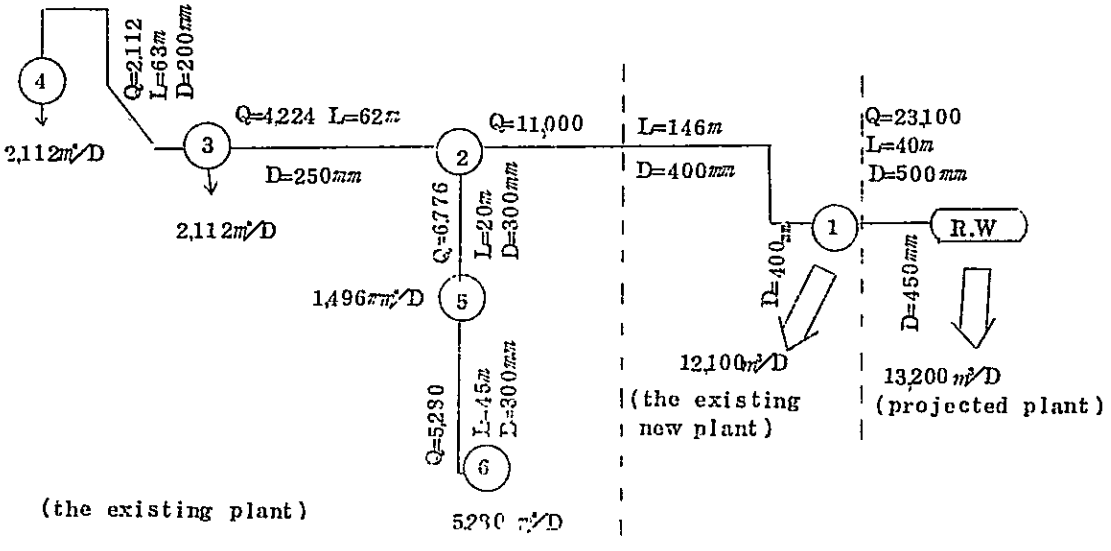
1) Measuring Apparatus Weir

Dimension: 1.0m (W) x 0.28m (H) ..... the existing plant

Dimension: 1.0m (W) x 0.19m (H) ..... the proposed plant

7-3-3 Supply Pipe for the Existing Plant

a.



b. Measuring System for Inlet Pipe

An venturimeter will be used where the flow exceeds 1 m/sec velocity.

Existing Plant

Sedimentation Basin	No. 4	ϕ150 mm	V=1.2 m/sec	Q=1,800-2,112 m^3/D
" "	No. 3	ϕ150 mm	V=1-1.2 m/sec	Q=1,800-2,112 m^3/D
" "	No. 5	ϕ100 mm	V=1-1.9 m/sec	Q= 780-1,496 m^3/D
" "	No. 6	ϕ200 mm	V=1-1.95 m/sec	Q=2,700-5,280 m^3/D
" "	No. 1	ϕ350 mm	V=1-1.45 m/sec	Q=8,200-12,200 m^3/D

Plant Projected for 1980

Sedimentation Basin	ϕ350 mm	V=1.44 m/sec	Q=12,000 m^3/D

7-3-4 Mixing Basin: 1

A propeller type flash mixer shall be installed.

Structure:	Reinforced Concrete
Dimension:	2.4m (W) x 2.4m (L) x 2.7m (H)
Capacity:	15.5 m^3
Retention Time:	1.68 min.
Mixer	Propeller Type
Motor:	1
Power:	2.2 kw

7-3-5 Flocculation Basin: 2

Flocculation basins are installed for use with mixing or sedimentation basins to aid the process of coagulation. The up-and-down type has been selected for planning. The flocculation chamber is planned to be built in batteries comprised of 2 sections.

Structure:	Reinforced Concrete
Dimension:	8m (W) x 12.0m (L) x 2.0m (H)
Capacity:	192 m^3 (Effective Capacity: 160 m^3)
Mean Velocity:	0.153 m/sec
Retention Time:	38.0 min

7-3-6 Horizontal Chemical Sedimentation Basin: 2

The plans specify use of horizontal chemical sedimentation basins, with a settling period of 3 hours and a mean velocity of less than 40cm/min. At the outlet, a trough will be installed to prevent overflow in event of an increase in unit discharge. A small insufficient unit discharge might cause a disturbance of flow, so that settled sludge would float upward.

Structure:	Reinforced Concrete
Dimension:	8.0m (W) x 31.5m (L) x 4.0m
Capacity:	1,008 m^3, 756 m^3 (Effective Capacity)
Retention Time:	180 min
Mean Velocity:	0.175 m/sec

a) Trough: 5

Structure:	F. R. P.
Dimension:	400 mm (W) x 350 mm (H) x 2.0m (L)

b) Sludge Removal

Design Standard (each chamber)

Quantity of water treated:	6,000 m^3/day
Turbidity:	100 ppm (mean)
	300 ppm (max.)
Aluminium Sulphate Feeding Ratio:	40 ppm (max.)

Drainage Concentration:	99%
Residual Solid:	5%

7-3-7 Rapid Sand Filter: 4 (including 1 spare).

Considering that turbidity is very high, a rapid sand filter was selected. The filtration rate, in Japan, is generally designed at 120 to 150 m/day, but taking into consideration of filter medium in Thailand a slower filter rate of 100 m/day was selected.

For the washing method, a combination of backwash and surface wash is selected and the necessary amount of water for washing is provided by an elevated tank.

Structure:	Reinforced Concrete	
Dimension:	3.20m x 2 (W) x 6.40m (L) x 4 (spare-1)	
Filter Area:	40 m^2	
Filtration Rate:	100 m/day	
Pipe Gallery		
Inlet Gate:	Dia. 350 mm	V = 0.48 m/sec
Outlet Pipe:	Dia. 300 mm	V = 0.65 m/sec
Back Wash		
Main Pipe:	Dia. 600 mm	V = 1.42 m/sec
Branch Pipe:	Dia. 500 mm	V = 2.05 m/sec
Surface Wash		
Main Pipe:	Dia. 400 mm	V = 1.06 m/sec
Branch Pipe:	Dia. 350 mm	V = 1.39 m/sec
Drain Pipe		
for washing:	Dia. 400 mm	
filter bottom:	Dia. 150 mm	

Overflow Pipe: Dia. 300 mm

Controller: Dia. 250 mm

7-3-8 Elevated Tank

An elevated tank will be necessary to supply wash water and water for the chlorine solution.

Structure: Reinforced Concrete

Dimension: 7.5m (W) x 7.5m (L) x 3.6m (H)

Capacity: 203 m^3

7-3-9 Chlorination Pump

Chlorine will be used as a disinfectant. Chlorine dosing shall be accomplished by means of an injector operated under pressure. Dosing shall be done at the outlet of the distribution pump.

Feeding Ratio: 5 ppm (max.) 3 ppm (mean) 2 ppm (min.)

Daily Demand: 12,000 m^3/day = 500 m^3/hour (3 x 500 = 1,500 g)

Hourly Demand: 18,000 m^3/day = 750 m^3/hour (5 x 750 = 3,750 g)

Mean Demand: 8,000 m^3/day = 333 m^3/hour (3 x 333 = 1,000 g)

Chlorine Solution Water (assuming that the concentration of chlorine used for dosing is 2,500 ppm)

$$18{,}000 \times \frac{5}{1{,}000{,}000} \times \frac{1{,}000{,}000}{2{,}500} = 36.0 \text{ m}^3\text{/day} = 0.025 \text{ m}^3\text{/min}$$

Head Loss: 20 m

Pump: 0.75 kw

7-4 Distribution Facilities

7-4-1 Outline

The distribution facilities consist of a clean water reservoir and distribution pipes. The reservoir is planned to be a rectangular structure

of reinforced concrete with a capacity of 3,000 m^3, equal to a quarter-day volume of the planned water delivery in 1980.

Next, to be considered are the distribution mains and served areas. Nakhon Rajasima is divided into two served areas for the 1st stage. One area is served from the existing water treatment plant; the other is planned to be served from the proposed water treatment plant which will be constructed near the existing plant. Furthermore the water treatment plant to be built in the succeeding 2nd stage has been tentatively located near the railway crossing to the west of this municipality, and will serve that area. After completion, this city will have three served ares within the administrative district.

These served areas are separated by several valves which can be operated to expand or reduce each served area.

Pipe lines are interconnected as much as possible and also they are connected to the distribution main with the branching system.

This report is limited to main pipelines, but adequate service to the people requires laying additional pipelines of 100 mm or less in diameter.

7-4-2 Clean Water Reservoir

Structure:	Reinforced Concrete
Dimension:	40m (W) x 25m (L) x 3.0m (Effective Height)
Capacity:	3,000 m^3
Number:	1

7-4-3 Distribution Pump

The planned capacity of distribution mains shall be sufficient to provide the hourly maximum demand. The hourly maximum demand was estimated as follows:

(hourly maximum demand) = (daily maximum demand) x 1.5

Thus the distribution pumps have been planned to be as follows:

7.2 m^3/min x 3 sets (including 1 spare)

7-4-4 Distribution Main

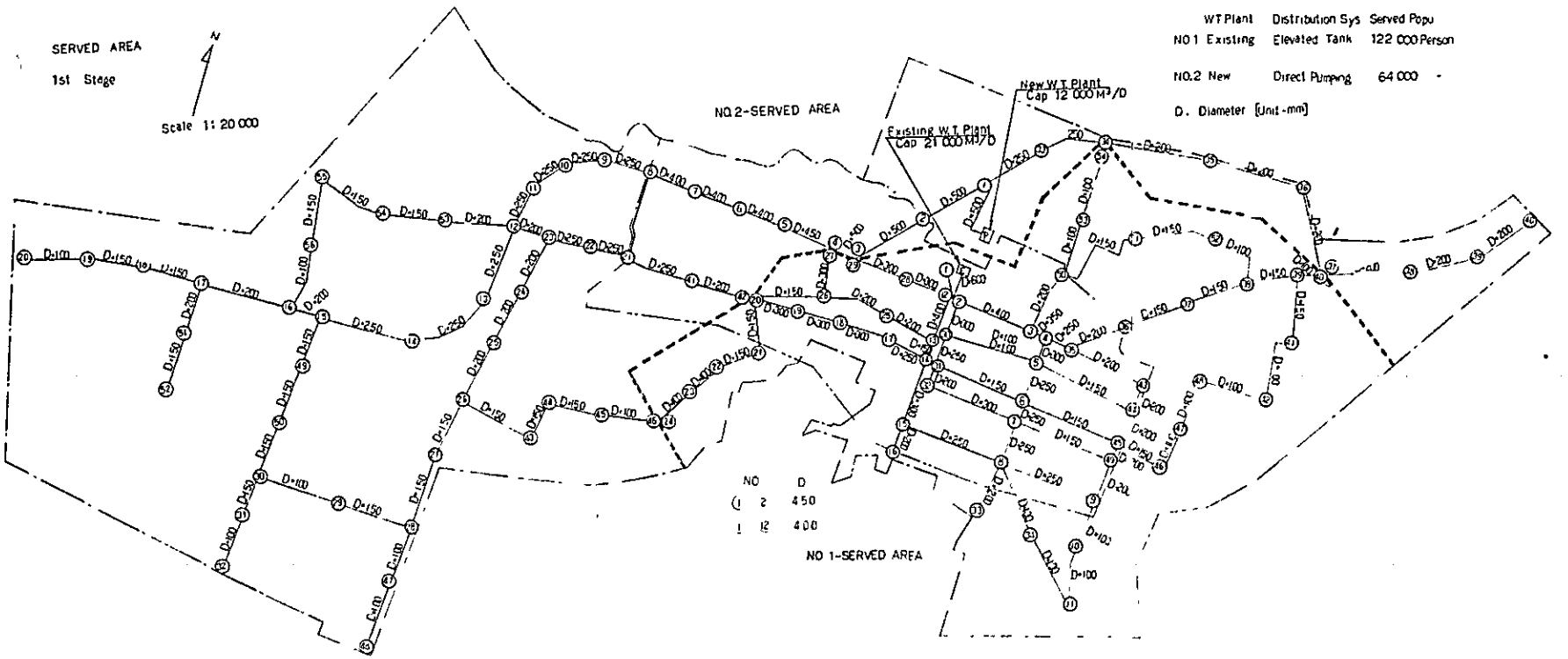
The pipeline length is shown in Table 7-1. Distribution mains are planned to be made of:

1) Mains over 350 mm D.: Mechanical-type Ductile Cast Iron Pipe

2) Mains under 300 mm D.: Asbestos Cement Pipe

Distribution pipes not more than 300mm should be asbestos cement pipe made in Thailand, the qualit of which is now adequate. Consequently the cost of laying pipe is estimated in foreign currency instead of local currency, freight and customs charge would increase final costs.

Almost of pipelines more than 350mm will be laid at main road. Then, MDCIP will be used instead of ACP. According to the increase of traffic in future, pipelines should be durable to the traific load. It is recomendable that, MDCIP is more proper pipes comparing to ACP. And, costs is estimated in foreign currency.


SERVED AREA
1st Stage
N
Scale 1: 20 000
NO.2-SERVED AREA
New W.T Plant
Cap 12 000 M³/D
Existing W.T Plant
Cap 21 000 M³/D
NO 1-SERVED AREA
WT Plant Distribution Sys Served Popu
NO 1 Existing Elevated Tank 122 000 Person
NO.2 New Direct Pumping 64 000
D. Diameter [Unit-mm]

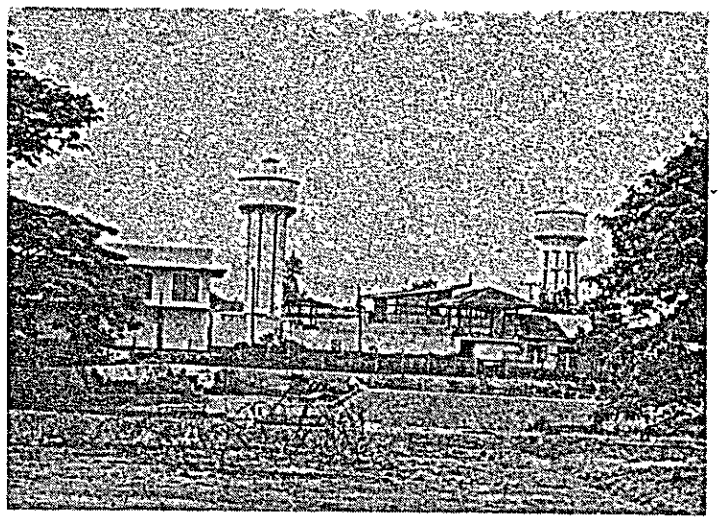
Nakhon Rajasima Served Area 1 (1st Stage)

From-To	C	L	D	Q	V	I	F.L.H	Sum H.	W.L.	G.L.	L.H.
0 - 1	130	150	600	322.00	1.14	1.937	0.291	0.29	199.71	177.00	22.71
1 - 2	"	40	450	188.24	1.18	2.913	0.117	0.41	199.59	"	22.59
2 - 3	"	650	400	132.84	1.06	2.712	1.763	2.17	197.83	"	20.83
3 - 4	"	130	350	95.59	0.99	2.827	0.368	2.54	197.46	"	20.46
4 - 5	"	250	300	52.57	0.74	1.981	0.495	3.04	196.96	"	19.96
5 - 6	"	350	250	35.21	0.72	2.294	0.803	3.84	196.16	"	19.16
6 - 45	"	840	136	17.70	0.53	2.672	2.245	6.09	193.91	"	16.91
45 - 46	"	400	125	6.07	0.49	2.595	1.038	7.13	192.87	"	15.87
46 - 47	"	375	100	4.57	0.58	4.550	1.706	8.84	191.16	"	14.16
47 - 48	"	375	100	3.57	0.45	2.882	1.081	9.92	190.08	"	13.08
48 - 42	"	550	100	2.57	0.33	1.569	0.863	10.78	189.22	"	12.22

Key to Abbreviations Used in Above Table:

C: Hazen-William's Coefficient
L: Length (m)
D: Pipe Diameter (mm)
Q: Quantity (l/sec)
V: Velocity (m/sec)
I: Hydraulic Gradient
F.L.H.: Friction Loss Head (m)
Sum H.: Sum Head (m)
W.L.: Water Level (m)
G.L.: Ground Level (m)
L.H.: Effective Head (m)

(Elevated Tank)



Nakhon Rajasima Served Area 2 (1st Stage)

From-To	C	L	D	Q	V	I	F.L.H.	Sum H	W.L.	G.L.	L.H.
0 - 1	130	550	500	245.50	1.28	2.969	1.633	1.63	220.37	177.00	43.37
1 - 2	"	600	500	215.50	1.13	2.346	1.408	3.04	218.96	"	41.96
2 - 3	"	410	500	210.50	1.10	2.239	0.918	3.96	218.04	"	41.04
3 - 4	"	250	500	202.00	1.05	2.079	0.520	4.48	217.52	"	40.52
4 - 5	"	450	450	192.00	1.24	3.168	1.426	5.91	216.09	"	39.09
5 - 6	"	400	450	182.00	1.14	2.737	1.095	7.00	215.00	"	38.00
6 - 7	"	400	450	167.00	1.05	2.334	0.934	7.93	214.07	"	37.07
7 - 8	"	400	450	152.00	0.96	1.961	0.784	8.71	213.29	"	36.29
8 - 9	"	300	250	46.24	0.94	3.798	1.139	9.85	212.15	"	35.15
9 - 10	"	350	250	44.74	0.91	3.573	1.251	11.10	210.90	"	33.90
10 - 11	"	350	250	43.24	0.88	3.354	1.174	12.27	209.73	"	32.73
11 - 12	"	350	250	41.74	0.85	3.142	1.100	13.37	208.63	"	31.63
12 - 13	"	700	250	40.94	0.83	3.032	2.122	15.49	206.51	"	29.51
13 - 14	"	700	250	38.44	0.78	2.698	1.889	17.38	204.62	"	27.62
14 - 15	"	700	250	35.94	0.73	2.383	1.668	19.05	202.95	"	25.95
15 - 16	"	480	200	24.50	0.78	3.477	1.669	20.72	201.28	"	24.28
16 - 17	"	800	200	26.00	0.83	3.881	3.104	23.82	198.18	"	21.18
17 - 18	"	520	150	9.00	0.51	2.213	1.151	24.97	197.03	"	20.03
18 - 19	"	520	150	6.00	0.49	2.540	1.321	26.29	195.71	"	18.71
19 - 20	"	520	100	3.00	0.38	2.089	1.086	27.38	194.62	"	17.62

Key to Abbreviations Used in Above Table:

C:	Hazen-William's Coefficient
L:	Length (m)
D:	Pipe Diameter (mm)
Q:	Quantity (l/sec)
V:	Velocity (m/sec)
I:	Hydraulic Gradient
F.L.H.:	Friction Loss Head (m)
Sum H.:	Sum Head (m)
W.L.:	Water Level (m)
G.L.:	Ground Level (m)
L.H.:	Effective Head (m)

Existing Pipe in Each Served Area (1st Stage)

Served Area - 1

Route	Existing Pipe		New Pipe	D = D' + d' (130)
	d (100)	d' (130)	D' (130)	
5 - 30	100	90	100	125
6 - 31	150	136		136
6 - 45	150	136		136
7 - 32	300	271		271
17 - 18	300	271		271
18 - 19	300	271		271
19 - 20	300	271		271
20 - 26	150	136		136
26 - 27	300	271		271
12 - 28	300	271		271
28 - 29	300	271		271
43 - 44	200	182		182
44 - 45	200	182		182
45 - 49	200	182		182
49 - 9	200	182		182

Served Area - 2

Route	Existing Pipe		New Pipe	D = D' + d' (130)
	d (100)	d' (130)	D' (130)	
41 - 42	200	182		182

8. Cost of Construction and Maintenance

1st Stage

8-1 Cost of Construction

In this section, estimated construction costs are calculated. In the following section, maintenance and operating costs are calculated.

8-1-1 Summary of Estimated Construction Cost

Totals of estimated constructions costs are given below. Construction costs are divided into foreign currency costs and domestic currency costs. Methods of calculating these costs are detailed latter.

Construction Cost

Unit: Baht

	Total Cost	Foreign Currency	Local Currency
1st Stage	88,800,000	44,500,000	44,300,000
2nd Stage	64,800,000 (97,200,000)	32,800,000 (49,200,000)	32,000,000 (48,000,000)
3rd Stage	16,200,000 (32,400,000)	5,000,000 (10,000,000)	11,200,000 (22,400,000)
Total	169,800,000 (218,400,000)	82,300,000 (103,700,000)	87,500,000 (114,700,000)

Note: ( ) escalated cost

2nd stage = 1st stage x 1.5

3rd stage = 1st stage x 2.0

Construction Cost

Unit: 1000¥

	Total Cost	Foreign Currency	Local Currency
1st Stage	1,598,400	801,000	797,400
2nd Stage	1,166,400 (1,749,600)	590,400 (885,600)	576,000 (864,000)
3rd Stage	291,600 (583,200)	90,000 (180,000)	201,600 (403,200)
Total	3,056,400 (3,931,200)	1,481,400 (1,866,600)	1,575,000 (2,064,600)

Construction Cost

Unit: U.S.$

	Total Cost	Foreign Currency	Local Currency
1st Stage	4,440,000	2,225,000	2,215,000
2nd Stage	3,240,000 (4,860,000)	1,640,000 (2,460,000)	1,600,000 (2,400,000)
3rd Stage	810,000 (1,620,000)	250,000 (500,000)	560,000 (1,120,000)
Total	8,490,000 (10,920,000)	4,115,000 (5,185,000)	4,375,000 (5,735,000)

8-1-1 Summary of Estimated Construction Costs

Items	1 : 1 Total Cost	Unit: Baht Foreign Currency	Local Currency	1 : 18 Total Cost	Unit Foreign Currency	1,000 ¥ Local Currency	1 : 1/20 Total Cost	Unit: U.S.$ Foreign Currency	Local Currency
Intake	2,400,000	1,800,000	600,000	43,200	32,400	10,800	120,000	90,000	30,000
Raw Water Main	31,000,000	24,000,000	7,000,000	558,000	432,000	126,000	1,550,000	1,200,000	350,000
Treatment Plant	9,900,000	2,300,000	7,600,000	178,200	41,400	136,800	495,000	115,000	380,000
Distribution	31,500,000	9,000,000	22,500,000	567,000	162,000	405,000	1,575,000	450,000	1,125,000
(Sub Total)	(74,800,000)	(37,100,000)	(37,700,000)	(1,346,400)	(667,800)	(678,600)	(3,740,000)	(1,855,000)	(1,885,000)
Engineering Fee (5%)	3,700,000	3,700,000	——	66,600	66,600	——	185,000	185,000	——
Administration Cost (4%)	2,900,000	——	2,900,000	52,200	——	52,200	145,000	——	145,000
Reserve (10%)	7,400,000	3,700,000	3,700,000	133,200	66,600	66,600	370,000	185,000	185,000
Grand Total	88,800,000	44,500,000	44,300,000	1,598,400	801,000	797,400	4,440,000	2,225,000	2,215,000
	100 %								

8-1-2 Breakdown of Construction Costs

Below is listed in order the types of facilities and construction costs.

1) Intake Facilities

2) Raw Water Mains

3) Treatment Plant

4) Water Distribution Facilities

1) Intake Facilities

(Unit: Baht)

	Items	Quantity	Total	Foreign Currency	Local Currency
1-1	Land Cost	400 m^2	8,000		8,000
1-2	Conduit Channel	5 m	32,000		32,000
1-3	Suction Well	93 m^3	62,000		62,000
1-4	Pump House	35 m^2	105,000		105,000
1-5	Pump Equipment	3 set	715,000	450,000	265,000
1-6	Diesel Engine	3 set	1,350,000	1,350,000	
1-7	Miscellaneous	(6%)	128,000		128,000
	Sub Total		2,400,000	1,800,000	600,000

2) Raw-water Main

	Items	Quantity	Total	Foreign Currency	Local Currency
2-1	MDCIP. ϕ600m/m Class - 2	15 km	28,125,000	23,625,000	4,500,000
2-2	Expenditure (20% of Local)		900,000	———	900,000
2-3	Pavement	10,000 m^2	450,000		450,000
2-4	Miscellaneous	5.2 %	1,525,000	375,000	1,150,000
	Sub Total		31,000,000	24,000,000	7,000,000

3) Water Treatment Plant

Unit: Baht

	Items	Quantity	Total	Foreign Currency	Local Currency
3-1	Receiving Well	1 set	720,000	303,000	417,000
3-2	Mixing Basin	1 set	39,000	25,000	14,000
3-3	Flocculation & Sedimentation Basin	1 set	2,900,000	80,000	2,820,000
3-4	Rapid Filter	160 m^2	2,100,000	900,000	1,200,000
3-5	Gallery	1	279,000	——	279,000
3-6	Elevated Tank	200 m^3	1,100,000	220,000	880,000
3-7	Management House	160 m^2	640,000	130,000	510,000
3-8	Chemical Feeder Equipment	1 set	440,000	——	440,000
3-9	Drainage	1 set	340,000	23,000	317,000
3-10	Pipe Arrangement in Plant	1 set	630,000	600,000	30,000
3-11	Miscellaneous	(6.4 %)	582,000	19,000	563,000
3-12	Land Cost	6,500 m^2	130,000	——	130,000
	Sub Total		9,900,000	2,300,000	7,600,000

4) Distribution System

	Items	Quantity	Total Cost	Foreign Currency	Local Currency
4-1	Pump House	168 m^2	504,000	0	504,000
4-2	Pump Equipment	3 sets	1,130,000	1,010,000	120,000
4-3	Electrical Equip.	1 set	905,000	480,000	425,000
4-4	Reservoir	3,000 m^3	2,700,000	0	2,700,000
4-5	MDCIP ϕ600m/m (Class-3)	150 m	256,500	215,850	40,650
4-6	" ϕ500m/m	1,810 m	2,324,040	1,954,800	369,240
4-7	" ϕ450m/m	490 m	529,200	445,900	83,300
4-8	" ϕ400m/m	2,250 m	2,047,500	1,710,000	337,500
4-9	" ϕ350m/m	1,010 m	757,500	626,200	131,300
4-10	A C P ϕ300m/m (Class-25)	1,160 m	436,160	———	436,160
4-11	" ϕ250m/m	8,930 m	2,571,840	———	2,571,840
4-12	" ϕ200m/m	11,840 m	2,581,120	———	2,581,120
4-13	" ϕ150m/m	14,060 m	2,249,600	———	2,249,600
4-14	" ϕ100m/m	11,730 m	1,173,000	———	1,173,000
4-15	Pavement	80,000 m^2	3,600,000	———	3,600,000
4-16	Valve Setting	307 sets	2,599,882	2,172,380	427,502
4-17	Miscellaneous	(6.2 %)	1,634,658	384,870	1,249,788
4-18	Expenditure (20% of local currency)		3,500,000		3,500,000
			31,500,000	9,000,000	22,500,000

5) Calculation of Construction Costs

Standard methods for calculating costs are as follows.

a. Calculations of construction costs include those facilities which will be completed at the 1st stage to full 1st Stage demand. The unit used is the Baht.

b. Standard unit costs for 1980 are estimated as 120% of unit costs by which materials and labour force could be acquired in 1965.

c. Construction costs are calculated taking into consideration the size of the various works, based on parallel examples in Japan.

d. Costs of materials, pumps, electric equipment, cast iron pipe, etc., which are imported from Japan include the prices C.I.F. Bangkok, landing costs and custom duties. In case the diameter of the pipe is less than 300 mm. asbestos cement pipe made in Thailand shall be used.

e. Land costs are calculated at 32,000 Baht per Rai, not including compensation costs.

f. Reserve funds for unforeseen costs shall be 10% of the construction cost.

g. Expendituresare estimated to be 20% of the local currency costs. These include supervision, office expenses, construction site expenses, and many other miscellaneous costs of local construction compenies and service organizations.

Administration costs of Thai Government agencies and its delegated representatives are estimated as 4% of total construction costs.

8-1-3 A Breakdown of Construction Funds

Funds required are broken down into foreign currency funds and local currency funds, as follows.

8-1-3 A Breakdown of Construction Funds

Items	1 : 1 Unit Baht				1 : 18 Unit 1000 ¥				1 : 1/20 Unit 1000 $			
	1972 AD		1973 AD		1972 AD		1973 AD		1972 AD		1973 AD	
	Foreign currency	Local currency	Foreign currency	Local currency	Foreign currency	Local currency	Foreign currency	Local currency	Foreign currency	Local currency	Foreign currency	Local currency
Intake	1,800,000	600,000	-	-	32,400	10,800	-	-	90	30	-	-
Raw-water main	24,000,000	7,000,000	-	-	432,000	126,000	-	-	1,200	350	-	-
Water Treatment Plant												
Receiving well	303,000	417,000	-	-	5,454	7,506	-	-	15.15	20.85	-	-
Mixing basin	-	-	25,000	14,000	-	-	450	252	-	-	1.25	0.70
Flocculation & Sedimentation	-	-	80,000	2,820,000	-	-	1,440	50,760	-	-	4.00	141.00
Rapid Sand Filter	-	-	300,000	1,200,000	-	-	16,200	21,600	-	-	45.00	60
Gallery	-	-	-	279,000	-	-	-	5,022	-	-	-	13.95
Elevated tank	-	-	220,000	880,000	-	-	3,960	15,840	-	-	11	44
Management House	-	-	130,000	510,000	-	-	2,340	9,180	-	-	6.5	25.5
Chemical Feeder	-	-	-	440,000	-	-	-	7,920	-	-	-	22
Drainage	-	-	23,000	317,000	-	-	414	5,706	-	-	1.15	15.85
Pipe arrangement in plant	600,000	30,000	-	-	10,800	540	-	-	30.00	1.5	-	-
Land cost	-	130,000	-	-	-	2,340	-	-	-	6.5	-	-
Miscellaneous	19,000	-	-	563,000	342	-	-	10,134	0.95	-	-	28.15
Distribution Facilities	-	-	9,000,000	22,500,000	-	-	162,000	405,000	-	-	450	1,125
Engineering Fee	3,700,000	-	-	-	66,600	-	-	-	185	-	-	-
Administration cost	-	1,450,000	-	1,450,000	-	26,100	-	26,100	-	72.5	-	72.5
Reserve	1,578,000	1,373,000	2,122,000	2,327,000	28,404	24,714	38,196	41,886	78.9	68.65	106.1	116.35
Total	32,000,000	11,000,000	12,500,000	33,300,000	576,000	198,000	225,000	599,400	1,600	550	625	1,665

8-2 Operating & Maintenance Cost

In this section, operating expenses for each year are indicated. Item 1 is Personnel Costs, item 2 is for Miscellaneous and Repair Expenditures, item 3 for Power Costs, and item 4 for Chemical Costs. Resing costs of commodities are provided by a 4% yearly increase for items 1, 2 and 3, and for a 5% yearly increase for Chemical Costs. These rates in commodity prices are based on the experience of recent years, but it is doubtful if the selected rates will accurately apply over the entire period of planning till AD 1980. Periodic revision may be desirable.

1) Personnel Expenditures.

Type of Work	Existing Plant		Planned New Plant	
	Workers (Person)	Salary (Baht)	Workers (person)	Salary (Baht)
Superintendent	1	1,500	1	1,500
Senior Attendant	2	2,200	1	1,100
Junior Attendant	2	2,000	1	1,000
Mechanics	6	5,400	2	1,800
Workers	10	5,400	3	1,620
Total (Month)	21	16,500	8	7,020
Total (Year)	252	198,000	96	84,240

Year	Personnel Expenditue (Baht)
1970	198,000
71	198,000
72	217,440
73	293,530
74	305,270
75	317,480
76	330,180
77	343,390
78	357,130
79	371,420
80	386,280

Remarks

* Including 4% annum escalation: 282,240 x 1.04 (A.D. 1973)

* Required Experience:

a) Superintendent Engineers: 5 yrs.

b) Senior Attendant & Technicians: 3 yrs.

c) Junior Attendant & Mechanics: 1 yr.

* Escalation is recomended to be put into effect in 1973

* In 1972, other 3 workers will be emplyed to be trained the operation for the proposed plant.
Personnel Expenditure = 198,000 + 540 x 3 x 12
= 217,440 Baht

2) Miscellaneous & Repair Expenditures

(Unit: Baht)

Year	Miscell-aneous	Repair Expenditure	Total	Remarks
1970	39,600	19,800	59,400	Miscellaneous expenditure
71	39,600	19,800	59,400	equal expenditure x 20 %
72	41,184	21,744	62,928	Repair expenses equal
73	58,706	29,353	88,059	personal expenses x 10 %
74	61,540	30,770	92,310	
75	63,498	31,749	95,247	(Experience in Japan)
76	66,036	33,018	99,054	
77	68,678	34,339	103,017	
78	71,426	35,713	107,139	
79	74,284	37,142	111,426	
80	77,256	38,628	115,884	

3) Power Cost

a) Plant Power Consumption

Apparatus Capacity	
Chemical Pump	2.2
Flash Mixer	2.2
Alum Solution Tank Mixer	3.7
Light	5
	= 13 kw

Operating Time 20 hours mean

$$p = (5 \times 6 + 8 \times 20) \times 365 = 69,350 \text{ kw}$$

b) Distribution Pump Power

Existing Power q = 250 m^3/H 55 kw U = 0.22 kwh

New Plant Power q = 432 m^3/H 75 kw U = 0.17 kwh

Unit Power per 1 m^3

$$\frac{2}{3} Q \times 0.22 + \frac{1}{3} Q \times 0.17 = 0.21 Q \text{ kwh}$$

Year	Mean Demand (m^3)	Unit Power (kwh)	Total Power (kw)
1970	4,635,500	0.22	1,019,810
71	4,891,000	0.22	1,076,020
72	5,157,450	0.22	1,134,639
73	5,434,850	0.21	1,141,318
74	5,719,550	0.21	1,201,105
75	6,007,900	0.21	1,261,659
76	6,299,900	0.21	1,322,979
77	6,599,200	0.21	1,385,832
78	6,905,800	0.21	1,450,218
79	7,219,700	0.21	1,516,137
80	7,555,500	0.21	1,586,655

c) Cost of Electricity

Unit Electric Rate: 0.7 Baht/kw

Year	Apparatus (kw)	Distributing (kw)	Total Power (kw)	Cost (B)
1970	———	1,019,810	1,019,810	713,867
71	———	1,076,020	1,076,020	753,214
72	———	1,134,639	1,134,639	794,247
73	69,350	1,141,318	1,210,668	847,468
74	69,350	1,201,105	1,270,455	889,312
75	69,350	1,261,659	1,331,009	931,706
76	69,350	1,322,979	1,392,329	974,630
77	69,350	1,385,832	1,455,182	1,018,627
78	69,350	1,450,218	1,519,568	1,063,698
79	69,350	1,516,317	1,585,667	1,109,967
80	69,350	1,586,655	1,656,005	1,159,203

d) Raw Water Pump Power

$Q = 12.6\ m^3/m = 756\ m^3/H$ 220 kw $U = \frac{220}{756} = 0.29$ kwh/m^3

Operated by Diesel Engine P = 310

Oil Quantity

262 ps x 190 g/H.ps = 49,780 g/H = 55,000 cc/H = 55 l/H

Specific Gravity 0.9 (crude petroleum)

Oil Cost 1 Baht/l

Unit Oil Power Cost 55 Baht/H x 1 set = 55 Baht/H

Operating Time $\frac{\text{Raw water demand} = 1.1\ Q}{\text{Pump cap : } 756 \times 2 = 1{,}512\ m^3/H}$

e) Oil Cost

Year	Daily		Annual	
	Mean Demand (m)	Operating Time (hours)	Operating Time (hours)	Cost (Baht)
1970	12,700 x 1.1	———	———	———
71	13,400 x 1.1	———	———	———
72	14.130 x 1.1	———	———	———
73	16,379	10.8	3,942	216,810
74	17,237	11.4	4,161	228,855
75	18,106	12	4,380	240,900
76	18,986	12.5	4,562.5	251,937
77	19,888	13.1	4,781.5	262,982
78	20,812	13.8	5,037	277,035
79	21,758	14.4	5,256	289,080
80	22,770	15	5,475	301,125

f) Total cost of Electricity and Oil

Year	Electricity	Oil	Total Cost (Baht)
1970	713,867	———	713,867
71	753,214	———	753,214
72	794,247	———	794,247
73	847,468	216,810	1,064,278
74	889,312	228,855	1,118,167
75	931,706	240,900	1,172,606
76	974,630	251,937	1,226,567
77	1,018,627	262,982	1,281,609
78	1,063,698	277,035	1,340,733
79	1,109,967	289,080	1,399,047
80	1,159,203	301,125	1,460,328

4) Chemical Cost

Year	Mean Demand (Ratio %)	Chemical Cost (Baht)	Escalation Ratio 5%	Annum Cost (Baht)
1970	100	625,792	1.0	625,792
71	105.5	660,211	1.05	693,221
72	111.3	696,507	1.10	766,157
73	117	732,177	1.21	885,934
74	123	769,724	1.27	977,550
75	130	813,530	1.33	1,081,994
76	136	851,077	1.40	1,191,508
77	142	888,625	1.47	1,306,278
78	149	932,431	1.54	1,435,943
79	156	976,236	1.62	1,581,503
80	163	1,020,042	1.70	1,734,071

Unit Cost per $1m^3$

Alum	60 ppm	0.06 kg x 1.5 Baht	= 0.09 Baht
Chlorine	3 ppm	0.03 x 10	= 0.03
Lime	3 ppm	0.03 x 0.5	= 0.015
			= 0.135 B/m^3

Annum Cost at 1970 AD

0.135^B x 4,635,500 = 625,792 Baht

Remarks: In 1973, escalation ratio is estimated 10%. This is caused by the washing of pipelines prepared for the biginning supply of water.

9. Financial Plan & Water Charges

9A Financial Plan and Water Charges by Amortization Method A

Water Charges 2.5 Baht/m^3

1) Interest

a) Foreign Currency

Interest Rate	4.0 %		
Term of Loan	20 years	Grace Period	5 years

b) Local Currency

Interest Rate	6.0 %		
Term of Loan	20 years	Grace Period	4 years

2) Principal

a) Foreign Currency Amortization in 15 equal annual payments

b) Local Currency Amortization in equal yearly payments over a 16 year period

9A-1 The Consumer Charges for Served Water from 1974 to 1980

A. Total Cost

1. Operation & Maintenance Cost

1)	Personal Expenses	(P. 49)	2,411,150
2)	Miscellaneous & Repair Expenses	(P. 50)	724,077
3)	Power Cost	(P. 53)	8,999,057
4)	Chemical Cost	(P. 53)	9,308,847
2.	Interest	(P. 62)	29,315,000
3.	Depreciation	(P. 59)	24,394,608
	Total		75,152,739

B. Total Measured and Charged Amount of water (P. 56) 32,415,285 m^3

C. Charge for Served Water

$$\frac{A}{B} = \frac{75,152,739}{32,415,285} = 2.32 = 2.5 \text{ Baht/m}^3$$

The revised consumer charges for served water an calculated above are recommended to be put into effect in 1974 in order to obtain revenue sufficient to balance expenses.

9A-1-1 Water charges

(a) Annual Water Supply Demand

Year	Mean Daily Demand (m^3)	Mean Annual Demand (m^3)	Effe. Ratio (%)	Mean Effe. Demand (m^3)	
1970	12,700	4,635,500	50	2,317,750	
71	13,400	4,891,000	50	2,445,500	
72	14,130	5,157,450	50	2,578,725	Supply Existing
73	14,890	5,434,850	60	3,260,910	Supply Opening
74	15,670	5,719,550	70	4,003,685	
75	16,460	6,007,900	70	4,205,530	
76	17,260	6,299,900	70	4,409,930	
77	18,080	6,599,200	70	4,619,440	
78	18,920	6,905,800	70	4,834,060	
79	19,780	7,219,700	70	5,053,790	
80	20,700	7,555,500	70	5,288,850	

(b) Annual Revenue from Water Charges

Year	Effe. Demand (m^3)	Unit Charge (Baht/m^3)	Revenue (Baht)
1970	2,317,750	1.5	3,476,625
71	2,445,500	1.5	3,668,250
72	2,578,725	1.5	3,868,086
73	3,260,910	1.5	4,891,365
74	4,003,685	2.5	10,009,125
75	4,205,530	2.5	10,513,825
76	4,409,930	2.5	11,024,825
77	4,619,440	2.5	11,548,600
78	4,834,060	2.5	12,085,150
79	5,053,790	2.5	12,634,475
80	5,288,850	2.5	13,222,125

(c) Daily Mean Supply

Year	Population			Mean Supply	Total Mean Supply
	Suburb	Municipal	Total		
1970	28,000	104,000	132,000	0.096	12,700
71	29,200	108,200	137,400	0.0975	13,400
72	30,400	112,400	142,800	0.0990	14,130
73	31,600	116,600	148,200	0.1005	14,890
74	32,800	120,800	153,600	0.1020	15,670
75	34,000	125,000	159,000	0.1035	16,460
76	35,200	129,200	164,400	0.1050	17,260
77	36,400	133,400	169,800	0.1065	18,080
78	37,600	137,600	175,200	0.108	18,920
79	38,800	141,800	180,600	0.1095	19,780
80	40,000	146,000	186,000	0.111	20,700

9A-1-2 Depreciation Accounting

Assets (Type)	Assets (Baht)	Ratio % (A)	Durable Year (years)	Depreciation Ratio % (B)	Conversion Depreciation Ratio (A x B)
Structure	19,147,000	21.5	58	1.8	0.387
Pipe & Fittings	64,067,000	72	38	2.7	1.944
Pumps, Electric, Measuring and Chemical Dosing Equipment	5,448,000	6.5	16	6.2	0.403
Total	88,662,000	100	-	-	2.734 = 2.7 %

a) Existing Plant Construction Costs (Estimated)

Example: Chiang Mai City (Unit: Baht)

Initial Construction	1,392,000	
1st Expansion	17,570,000	
2nd Expansion	5,900,000	
Total	24,962,000	(Q = 14,880 m^3/d)
Unit Cost per 1 m^3	1,678 Baht	

b) Nakhon Rajasima Municipality Existing Plant Capacity

$Q = 24{,}000\ m^3/d$

Construction Cost 40,272,000 Baht

Depreciation $40{,}272{,}000 \times 0.9 \times 0.03 = 1{,}087{,}344$ Baht

c) Construction Expenses

	Machinery Electrical Equipment, and Instrument	Piping & Fittings	Other Works
Intake	2,065,000	-	327,000
Raw Water Main	-	30,550,000	450,000
Treatment Plant	479,000	630,000	8,661,000
Distribution	2,035,000	22,661,000	6,804,000
Sub Total	4,579,000	53,841,000	16,242,000
Engineering Fee (5%)	228,000	2,690,000	782,000
Administration Cost (4%)	183,000	2,152,000	565,000
Reserve (10%)	458,000	5,384,000	1,558,000
Total	5,448,000	64,067,000	19,147,000

9A-1-2 Depreciation (Unit: Baht) Annual Average: 3%
Residual Value: 10%

	Existing Plant	1972 (New Plant)	1973 (New Plant)	Total
Property Cost	40,272,000	43,000,000	45,800,000	
Depreciation (0.9 x 0.03)	1,087,344	1,161,000	1,236,600	
1970	1,087,344	0	0	1,087,344
71	1,087,344	0	0	1,087,344
72	1,087,344	0	0	1,087,344
73	1,087,344	1,161,000	0	2,248,344
74	1,087,344	1,161,000	1,236,600	3,484,944
75	1,087,344	1,161,000	1,236,600	3,484,944
76	1,087,344	1,161,000	1,236,600	3,484,944
77	1,087,344	1,161,000	1,236,600	3,484,944
78	1,087,344	1,161,000	1,236,600	3,484,944
79	1,087,344	1,161,000	1,236,600	3,484,944
80	1,087,344	1,161,000	1,236,600	3,484,944

9A-1-3 Amortization Schedule (Foreign Currency)

Interest Rate 4.0%
Term of Loan 20 years
Grace Period 5 years

	1 : 1				Unit : 1,000 Baht	
Principal	32,000		12,500			
Borrowing	1972 A D		1973 A D			
Year	Principal	Interest	Principal	Interest	Total Principal	Total Interest
1972	0	0	-	-	0	0
73	0	1,280	0	0	0	1,280
74	0	1,280	0	500	0	1,780
75	0	1,280	0	500	0	1,780
76	0	1,280	0	500	0	1,780
77	2,133.3	1,280	0	500	2,133,333	1,780
78	2,133.3	1,180	833,333	500	2,966,633	1,680
79	2,133.3	1,095	833,333	499	2,966,633	1,594
80	2,133.3	1,010	833,333	466	2,966,633	1,476
81	2,133.3	925	833,333	433	2,966,633	1,358
82	2,133.3	840	833,333	400	2,966,633	1,240
83	2,133.3	755	833,333	367	2,966,633	1,122
84	2,133.3	670	833,333	330	2,966,633	1,000
85	2,133.3	585	833,333	297	2,966,633	882
86	2,133.3	500	833,333	264	2,966,633	764
87	2,133.3	415	833,333	231	2,966,633	646
88	2,133.3	330	833,333	198	2,966,633	528
89	2,133.3	245	833,333	165	2,966,633	410
90	2,133.3	160	833,333	99	2,966,633	259
91	2,133.3	85	833,333	66	2,966,633	151
92	-	-	833,333	33	833,333	33

Amortization Schedule (Local Currency)

Interest Rate 6%
Term of Loan 20 year's
Crace Period 4 year's

	1 : 1			Unit 1,000 Baht		
Principal Borrowing Year	11,000		33,300			
	1972 A D		1973 A D		Total Principal	Total Interest
	Principal	Interest	Principal	Interest		
1972	0	0	-	-	0	0
73	0	660	0	0	0	660
74	0	660	0	1,998	0	2,658
75	0	660	0	1,998	0	2,658
76	687.5	660	0	1,998	687.5	2,658
77	687.5	618.75	2,081.25	1,998	2,768.25	2,616.75
78	687.5	577.5	2,081.25	1,873.125	2,768.75	2,450.625
79	687.5	536.25	2,081.25	1,748.250	2,768.75	2,284.5
80	687.5	495	2,081.25	1,623.375	2,768.75	2,118.375
81	687.5	453	2,081.25	1,498.5	2,768.75	1,951.5
82	687.5	412.5	2,081.25	1,373.625	2,768.75	1,286.125
83	687.5	371	2,081.25	1,248.75	2,268.75	1,619.75
84	687.5	330	2,081.25	1,623.875	2,768.75	1,453.875
85	687.5	288.75	2,081.25	999	2,768.75	1,287.75
86	687.5	247.5	2,081.25	874.125	2,268.75	1,121.625
87	687.5	206.25	2,081.25	749.250	2,768.75	955.5
88	687.5	165	2,081.25	624.375	2,768.75	789.375
89	687.5	123.75	2,081.25	499.5	2,768.75	623.25
90	687.5	82.5	2,081.25	374.625	2,768.75	457.125
91	687.5	41	2,081.25	249.75	2,768.75	290.75
92	-	-	2,081.25	124.875	2,081.25	124.875

Amortization Schedule

Totals of Principal and Interests

(Unit: Baht)

	Principal			Interest		
	Foreign Currency	Local Currency	Total	Foreign Currency	Local Currency	Total
Year 1972	0	0	0	0	0	0
1973	0	0	0	1,280	660	1,940
1974	0	0	0	1,780	2,658	4,438
1975	0	0	0	1,780	2,658	4,438
1976	0	687.5	687.5	1,780	2,658	4,438
1977	2,133.333	2,768.75	4,902.083	1,780	2,616.75	4,396.75
1978	2,966.633	2,768.75	5,735.383	1,680	2,450.625	4,130.75
1979	2,966.633	2,768.75	5,735.383	1,594	2,284.5	3,878.5
1980	2,966.633	2,768.75	5,735.383	1,476	2,118.375	3,594.375
1981	2,966.633	2,768.75	5,735.383	1,358	1,951.5	3,309.5
1982	2,966.633	2,768.75	5,735.383	1,240	1,786.175	3,026.175
1983	2,966.633	2,768.75	5,735.383	1,122	1,619.75	2,741.75
1984	2,966.633	2,768.75	5,735.383	1,000	1,453.875	2,453.875
1985	2,966.633	2,768.75	5,735.383	882	1,287.75	2,169.75
1986	2,966.633	2,768.75	5,735.383	764	1,121.625	1,885.625
1987	2,966.633	2,768.75	5,735.383	646	955.5	1,601.5
1988	2,966.633	2,768.75	5,735.383	528	789.375	1,317.375
1989	2,966.633	2,768.75	5,735.383	410	623.25	1,033.25
1990	2,966.633	2,768.75	5,735.383	259	457.125	716.125
1991	2,966.633	2,768.75	5,735.383	151	290.75	441.75
1992	833.333	2,081.25	2,914.583	33	124.875	157.875

9A-2 Financial Plan

9A-2-1 Statement of Operating Balance

Unit 1,000 Baht

Year	Water Charges	Operating & Maintenance Expenses							Surplus	Remarks
		Personnel	Miscellaneus, Repair & Expansion	Power	Chemicals	Interest	Depreciation	Total		
1970	3,477	198	59	714	626	0	1,088	2,685	792	
1971	3,668	198	59	753	693	0	1,088	2,791	877	
1972	3,868	217	62	794	766	0	1,088	2,927	941	
1973	4,891	294	88	1,064	886	1,940	2,240	6,520	1,629	Deficit
1974	10,009	305	92	1,118	978	4,438	3,485	10,416	407	Deficit
1975	10,514	317	95	1,173	1,082	4,438	3,485	10,590	76	Deficit
1976	11,025	330	99	1,227	1,192	4,438	3,485	10,771	254	
1977	11,549	343	103	1,282	1,306	4,397	3,485	10,916	633	
1978	12,085	357	107	1,341	1,436	4,131	3,485	10,857	1,228	
1979	12,634	371	111	1,399	1,582	3,879	3,485	10,827	1,807	
1980	13,222	386	116	1,460	1,734	3,594	3,485	10,775	2,447	
Total	96,942	3,316	991	12,325	12,281	31,255	29,907	90,075	6,867	

9A-2-2 Statement of Cash Flow

Unit : 1,000 Baht

Year	Sources of Funds					Disbursements				Balance	Cumulative Balance
	Borrowings		Reserve for Depreciation	Surplus over Operating Expenses	Total	Construction Costs	Amortization of Principal	Deficit over Operating Expenses	Total		
	(Local Fund)	(Foreign Fund)									
1970	0	0	1,088	792	1,880	0	0	0	0	1,880	1,880
1971	0	0	1,088	877	1,965	0	0	0	0	1,965	3,845
1972	11,000	32,000	1,088	941	45,029	43,000	0	0	43,000	2,029	5,874
1973	33,300	12,500	619	0	46,419	45,800	0	1,629	47,429	*1,010	4,864
1974	0	0	3,078	0	3,078	0	0	407	407	2,671	7,535
1975	0	0	3,409	0	3,409	0	0	76	76	3,333	10,868
1976	0	0	3,485	254	3,739	0	688	0	688	3,051	13,919
1977	0	0	3,485	633	4,118	0	4,902	0	4,902	* 784	13,135
1978	0	0	3,485	1,228	4,713	0	5,735	0	5,735	*1,022	12,113
1979	0	0	3,485	1,807	5,292	0	5,735	0	5,735	* 443	11,670
1980	0	0	3,485	2,447	5,932	0	5,735	0	5,735	197	11,867
Total	44,300	44,500	27,795	8,979	125,574	88,800	22,795	2,512	114,107	11,867	-

Note: * means "Deficit"

9B Financial Plan and Water Charges by Amortization Method B.

Water Charges 2.5 Baht/m^3

Interest

Foreign Currency

Interest Rate: 4.0 %

Term of Loan: 20 years

Grace Period: 5 years

Local Currency

Interest Rate: 8.0 %

Term of Loan: 30 years

Grace Period: 5 years

Principal

Foreign Currency - Amortization in 15 equal annual payments

Local Currency -

6th - 10th years - 2% of principal per year

11th - 25th years - 4% of principal per year

26th - 30th years - 6% of principal per year

9B-1 Consumer Charges for Served Water from 1974 to 1980

A. Total Cost

1. Operation & Maintenance Cost			
1) Personal Expenses	(P.49)		2,411,150
2) Miscellaneous & Repair Expenses		(P.50)	724,077
3) Power Cost	(P.53)		8,999,057
4) Chemical Cost	(P.53)		9,308,847
2. Interest	(P.69)		36,415,000
3. Depreciation	(P.59)		24,394,608
Total			82,252,739

B. Total Measured and Charged Amount of Water

(P.56) 32,415,285 m^3

C. Charges for Served Water

$$\frac{A}{B} = \frac{82,252,739}{32,415,285} = 2.54 = 2.5 \text{ Baht}/m^3$$

The revised consumer charges for served water as calculated above are recommended to be put into effect 1973 in order to obtain revenue sufficient to balance expenses.

9B-1-1 Amortization Schedule (Foreign Currency)

Unit: 1,000 Baht

Principal Borrowing Year / Year	32,000 1972 A.D.		12,500 1973 A.D.		Total	Total
	Principal	Interest	Principal	Interest	Principal	Interest
1972	0	0	-	-	0	0
1973	0	1,280	0	0	0	1,280
1974	0	1,280	0	500	0	1,780
1975	0	1,280	0	500	0	1,780
1976	0	1,280	0	500	0	1,780
1977	2,133.3	1,280	0	500	2,133.333	1,780
1978	2,133.3	1,180	833.333	500	2,966.633	1,680
1979	2,133.3	1,095	833.333	499	2,966.633	1,594
1980	2,133.3	1,010	833.333	466	2,966.633	1,476
1981	2,133.3	925	833.333	433	2,966.633	1,358
1982	2,133.3	840	833.333	400	2,966.633	1,240
1983	2,133.3	755	833.333	367	2,966.633	1,122
1984	2,133.3	670	833.333	330	2,966.633	1,000
1985	2,133.3	585	833.333	297	2,966.633	882
1986	2,133.3	500	833.333	264	2,966.633	764
1987	2,133.3	415	833.333	231	2,966.633	646
1988	2,133.3	330	833.333	198	2,966.633	528
1989	2,133.3	245	833.333	165	2,966.633	410
1990	2,133.3	160	833.333	99	2,966.633	259
1991	2,133.3	85	833.333	66	2,966.633	151
1992	-	-	833.333	33	833.333	33

9B-1-2 Amortization Schedule (Local Currency)

Principal Borrowing Year Year	11,000		33,000		Unit: 1,000 Baht	
	1972 A.D.		1973 A.D.		Total	Total
	Principal	Interest	Principal	Interest	Principal	Interest
1972	0	0	-	-	0	0
1973	0	880.0	0	0	0	880
1974	0	880.0	0	2,664	0	3,544
1975	0	880.0	0	2,664	0	3,544
1976	0	880.0	0	2,664	0	3,544
1977	220	880.0	0	2,664	220	3,544
1978	220	862.4	666	2,664	886	3,526.4
1979	220	844.8	666	2,612.2	886	3,457.0
1980	220	827.2	666	2,558.9	886	3,386.1
1981	220	809.6	666	2,505.6	886	3,315.2
1982	440	792.0	666	2,452.3	1,106	3,244.3
1983	440	756.8	1,332	2,399.0	1,772	3,155.8
1984	440	721.6	1,332	2,292.4	1,772	3,014.0
1985	440	686.4	1,332	2,185.8	1,772	2,872.2
1986	440	651.2	1,332	2,079.2	1,772	2,730.4
1987	440	616.0	1,332	1,972.6	1,772	2,588.6
1988	440	580.8	1,332	1,866.0	1,772	2,446.8
1989	440	545.6	1,332	1,759.4	1,772	2,305.0
1990	440	510.4	1,332	1,652.8	1,772	2,163.2
1991	440	575.2	1,332	1,546.2	1,772	2,021.4
1992	440	440.0	1,332	1,439.6	1,772	1,879.6
1993	440	404.8	1,332	1,333.0	1,772	1,737.8
1994	440	369.6	1,332	1,226.4	1,772	1,596.0
1995	440	334.4	1,332	1,119.8	1,772	1,454.2
1996	440	299.2	1,332	1,013.2	1,772	1,312.4
1997	660	264.0	1,332	906.6	1,992	1,170.6
1998	660	211.2	1,998	800	2,658	1,011.2
1999	660	118.4	1,998	640	2,658	758.4
2000	660	105.6	1,998	480	2,658	585.6
2001	660	152.8	1,998	320	2,658	372.8
2002	-	-	1,998	160	1,998	160

9B-1-3 Amortization Schedule
(Totals Foreign Currency and Local Currency)

(Unit: 1,000 Baht)

Currency	Foreign Currency		Local Currency		Total	
	Principal	Interest	Principal	Interest	Principal	Interest
Year						
1972	0	0	0	0	0	0
1973	0	1,280	0	880	0	2,160
1974	0	1,780	0	3,544	0	5,324
1975	0	1,780	0	3,544	0	5,324
1976	0	1,780	0	3,544	0	5,324
1977	2,133.333	1,780	220	3,544	2,350.333	5,324
1978	2,966.633	1,680	886	3,526.4	3,852.633	5,206.4
1979	2,966.633	1,594	886	3,457.0	3,852.633	5,051
1980	2,966.633	1,476	886	3,386.1	3,852.633	4,862.1
1981	2,966.633	1,358	886	3,315.2	3,852.633	4,673.2
1982	2,966.633	1,240	1,106	3,244.3	4,072.633	4,484.3
1983	2,966.633	1,122	1,772	3,155.8	4,738.633	4,277.8
1984	2,966.633	1,000	1,772	3,014.0	4,738.633	4,014.0
1985	2,966.633	882	1,772	2,872.2	4,738.633	3,754.2
1986	2,966.633	764	1,772	2,730.4	4,738.633	3,494.4
1987	2,966.633	646	1,772	2,588.6	4,738.633	3,234.6
1988	2,966.633	528	1,772	2,446.8	4,738.633	2,974.8
1989	2,966.633	410	1,772	2,305.0	4,738.633	2,715.0
1990	2,966.633	259	1,772	2,163.2	4,738.633	2,422.2
1991	2,966.633	151	1,772	2,021.4	4,738.633	2,172.4
1992	833.333	33	1,772	1,879.6	2,605.333	1,912.6
1993			1,772	1,737.8	1,772	
1994			1,772	1,596.0	1,772	
1995			1,772	1,454.2	1,772	
1996			1,772	1,312.4	1,772	
1997			1,992	1,170.6	1,992	
1998			2,658	1,011.2	2,658	
1999			2,658	758.4	2,658	
2000			2,658	585.6	2,658	
2001			2,658	372.8	2,658	
2002			1,998	160	1,998	

9B-2: Financial Plan
9B-2-1: Statement of Operating Balance

Unit: 1,000 Baht

		Operating and Maintenance Expenditure								
	Water		Miscellaneous							
Year	Charges	Personnel Exp.	Repair Exp.	Electricity	Chemical	Interest	Depriciation	Total	Surplus	Remarks
1970	3,477	198	59	714	626	0	1,088	2,685	792	
1971	3,668	198	59	753	693	0	1,088	2,791	877	
1972	3,868	217	62	794	766	0	1,088	2,927	941	
1973	4,891	294	88	1,064	886	2,160	2,248	6,740	1,849	Deficit
1974	10,009	305	92	1,118	978	5,324	3,485	11,302	1,293	Deficit
1975	10,514	317	95	1,173	1,082	5,324	3,485	11,476	962	Deficit
1976	11,025	330	99	1,227	1,192	5,324	3,485	11,657	632	Deficit
1977	11,549	343	103	1,282	1,306	5,324	3,485	11,843	294	Deficit
1978	12,085	357	107	1,341	1,436	5,206	3,485	11,932	153	
1979	12,634	371	111	1,399	1,582	5,051	3,485	11,999	635	
1980	13,222	386	116	1,460	1,734	4,862	3,485	12,043	1,179	
Total	96,942	3,316	991	12,325	12,281	38,575	29,907	97,395	453	Deficit

9B-2-2 Statement of Cash Flow

Unit: 1,000 Baht

	Sources of Funds										
	Borrowing		Reserve	Surplus		Const-	Amorti-	Deficit over			
	Local	Foreign	for Depre-	over Opera-		ruction	zation of	Operating			Cumulative
Year	Funds	Funds	ciation	ting Exp.	Total	Cost	Principal	Expenses	Total	Balance	Balance
1970			1,088	792	1,880	0	0	0	0	1,880	1,880
1971			1,088	877	1,965	0	0	0	0	1,965	3,845
1972	11,000	32,000	1,088	941	45,029	43,000	0	0	43,000	2,029	5,874
1973	33,300	12,500	399	0	46,199	45,800	0	1,849	47,649	1,	4,424
1974			2,192	0	2,192	0	0	1,293	1,293	899	5,323
1975			2,523	0	2,523	0	0	962	962	1,571	6,894
1976			2,858	0	2,858	0	0	632	632	2,226	9,120
1977			3,191	0	3,191	0	2,353	294	2,641	544	9,664
1978			3,485	153	3,638	0	3,853	0	3,853	215	9,449
1979			3,485	635	4,120	0	3,853	0	3,853	267	9,716
1980			3,485	1,179	4,664	0	3,853	0	3,853	801	10,517
Total	44,300	44,500	24,882	4,577	118,259	88,800	13,912	5,030	107,742	10,517	

Remarks: * Deficit

10. Cost of Construction

2nd Stage

10-1 Summary of Estimated Construction Cost

(Unit: Baht)

Items	Total Cost	Foreign Currency	Local Currency
Intake	220,000	0	220,000
Raw-Water main	18,700,000	14,500,000	4,200,000
Treatment Plant	9,700,000	2,000,000	7,700,000
Distribution	26,000,000	10,900,000	15,100,000
(Sub Total)	54,620,000	27,400,000	27,220,000
Engineering Fee (5%)	2,700,000	2,700,000	-
Administration Cost (4%)	2,100,000	-	2,100,000
Reserve (10%)	5,380,000	2,700,000	2,680,000
Grand Total	64,800,000	32,800,000	32,000,000

10-2 Breakdown of Construction Costs

1) Intake

Items	Quantity	Total	Foreign Currency	Local Currency
Land Cost	200 m^2	4,000	-	4,000
Conduit	5 m	32,000	-	32,000
Suction Well	93 m^3	62,000	-	62,000
Pump House	35 m^2	105,000	-	105,000
Pump Equipment	-	-	-	-
Generator & House	-	-	-	-
Miscellaneous	(7.9%)	17,000	-	17,000
Sub Total		220,000	0	220,000

2) Raw-water Main

Items	Quantity	Total	Foreign Currency	Local Currency
M.D.C.I.P ϕ600 mm Class-3	10 km	17,100,000	14,400,000	2,700,000
Expenditure	(20% of Local)	54,000		54,000
Pavement	7,000 m^2	315,000		315,000
Miscellaneous	8 %	1,231,000	100,000	1,131,000
Sub Total		18,700,000	14,500,000	4,200,000

3) Water-Treatment Plant

Unit: Baht

Item	Quantity	Total	Foreign Currency	Local Currency
Land Cost	13,000 m^2	260,000	-	260,000
Receiving Well	1 set	720,000	303,000	417,000
Mixing Basin	1 set	39,000	25,000	14,000
Floculation & Sedimentation Basin	1 set	2,900,000	80,000	2,820,000
Rapid Filter	160 m^2	2,100,000	900,000	1,200,000
Gallery	1	279,000	-	279,000
Elevated Tank	200 m^3	1,100,000	220,000	880,000
Management House	160 m^2	640,000	130,000	510,000
Chemical Feeder Equipment	1 set	440,000	-	440,000
Drainage	1 set	340,000	23,000	317,000
Pipe Arrangement in Plant	1 set	330,000	300,000	30,000
Miscellaneous	(9.4 %)	552,000	19,000	533,000
Sub Total		9,700,000	2,000,000	7,700,000

4) Distrubution System

Unit: Baht

Item	Quantity	Total	Foreign Currency	Local Currency
Pump House	168 m^2	504,000	0	504,000
Pump Equipment	5 sets	1,910,000	1,550,000	360,000
Electrical Equip.	1 set	710,000	480,000	230,000
Reservoir	3,000 m^3	2,700,000	0	2,700,000
MDCIP ϕ 600 m/m (Class-3)	1,950 m	3,334,500	2,806,050	528,450
ϕ 450 m/m	1,080 m	1,166,400	982,800	183,600
ϕ 400 m/m	2,750 m	2,502,500	2,090,000	412,500
ϕ 350 m/m	1,600 m	1,200,000	992,000	208,000
A C P ϕ 300 m/m	5,550 m	2,086,800	-	2,086,800
ϕ 250 m/m	7,680 m	2,211,840	-	2,211,840
ϕ 200 m/m	5,340 m	1,164,120	-	1,164,120
ϕ 150 m/m	2,750 m	440,000	-	440,000
Valve Setting				
ϕ 600 m/m	2 sets	140,616	122,360	18,256
ϕ 450 m/m	5 sets	179,765	147,140	32,625
ϕ 400 m/m	13 sets	363,974	293,748	70,226
ϕ 350 m/m	8 sets	142,440	136,240	6,200
ϕ 300 m/m	25 sets	349,825	334,750	15,075
ϕ 250 m/m	38 sets	339,340	320,492	18,848
ϕ 200 m/m	26 sets	165,698	154,960	10,738
ϕ 150 m/m	14 sets	63,210	58,100	5,110
Miscellaneous	(7.5 %)	1,637,972	431,360	1,206,612
Expenditure	(20% of Local)	2,687,000	-	2,687,000
Sub Total		26,000,000	10,900,000	15,100,000

11. Cost of Construction

3rd Stage

11-1 Summary of Estimated Construction Cost

(Unit: Baht)

Items	Total Cost	Foreign Currency	Local Currency
Intake	1,500,000	1,300,000	200,000
Raw-water Main	-	-	-
Water Treatment Plant	6,500,000	1,500,000	5,000,000
Distribution	5,600,000	1,100,000	4,500,000
(Sub Total)	13,600,000	3,900,000	9,700,000
Engineering Fee (5%)	680,000	680,000	
Administration Cost (4%)	540,000	-	540,000
Reserve (10%)	1,380,000	420,000	960,000
Grand Total	16,200,000	5,000,000	11,200,000

11-2 Breakdown of Construction Costs

1) Intake & Grit Chamber Plant

Unit: Baht

Items	Quantity	Total	Foreign Currency	Local Currency
Land Cost	-	-	-	-
Conduit Channel	-	-	-	-
Suction Well	-	-	-	-
Pump House	-	-	-	-
Pump Equipment	2 sets	410,000	240,000	170,000
Diesel-Engine	2 sets	1,000,000	1,000,000	0
Miscellaneous	(6.3 %)	90,000	60,000	30,000
Sub-Total		1,500,000	1,300,000	200,000

2) Raw-Water Main

Items	Quantity	Total	Foreign Currency	Local Currency
-	-	-	-	-
Sub-Total	-	-	-	-

3) Water-Treatment Plant

Unit: Baht

Items	Quantity	Total	Foreign Currency	Local Currency
Land Cost	——	—	——	——
Receive Well	——	—	——	——
Mixing Basin	1 set	39,000	25,000	14,000
Floculation & Sedimentation Basin	1 sets	2,900,000	80,000	2,820,000
Rapid Filter	160 m^2	2,100,000	900,000	1,200,000
Gallery	1 m^2	279,000	-	279,000
Elevated Tank	-	-	-	-
Management house	-	-	-	-
Chemical Feeder Equipment	-	-	-	-
Drainage	1 set	340,000	23,000	317,000
Pipe Arrangement in Plant	1 set	330,000	300,000	30,000
Miscellaneous	8.5 %	512,000	172,000	340,000
Sub Total		6,500,000	1,500,000	5,000,000

4) Distribution System

Items	Quantity	Total	Foreign Currency	Local Currency
Pump House	168 m^2	504,000	0	504,000
Pump Equipment	2 sets	780,000	620,000	160,000
Electrical Equipment	1 set	680,000	480,000	200,000
Reservoir	3,000 m^3	2,700,000	0	2,700,000
Miscellaneous	(5.5%)	256,000	0	256,000
Expenditure	(20% of Local)	680,000	-	680,000
Sub Total		5,600,000	1,100,000	4,500,000

12. Rehabilitation Works

12. Rehabilitation Work on the Provincial Water Supply System

The Nakhon-Rajasima Water Supply System urgently requires rehabilitation work on the present water supply system as recommended in this report. Emphasis should be on training of operators, supervisors and engineers, so that at all time responsible personnel are available.

12-1 Existing Water Treatment Plant

The following equipment is absolutely necessary to equip existing facilities to perform in a normal fashion.

1) Accurate chemical dosing equipment such as alum flush mixing equipment and lime feeding apparatus.
2) Baffle walls for sedimentation basins including inlet, intermediate and outlet walls.
3) Supplementary filter beds in addition to the present filters which are all under continual operation.
4) Flow controller installed at the inlet pipe of the filter.
5) Replace the present inferior filter sand with more suitable sand meeting engineering standards.
6) Continuous testing of the amount of residual chlorine in the purified water.

12-2 Elimination of Leakage and Unmeasured Water Throughout the Distribution System.

Almost 30 to 50% of the total supply of treated water throughout the distribution system is reported to be lost by leakage or unmeasured. To correct this condition, it would be desirable to initiate a special 5 to 10 year program, which should include immediate training of engineers and technicians.

12-3 Routine Check on Vital Statistics

Under the accelerated program of development in the municipalities, there are many changes of population, accompanying industrialization, urbanization and other movements of inhabitants. Therefore, it will be necessary to make a routine check yearly on actual population, on population to be supplied, and the percent of houses with water connections. This study should be carefully evaluated and used in planning the extension projects for 1990 AD and 2000 AD.

I. Existing Water Treatment Plants (Unit : Baht)

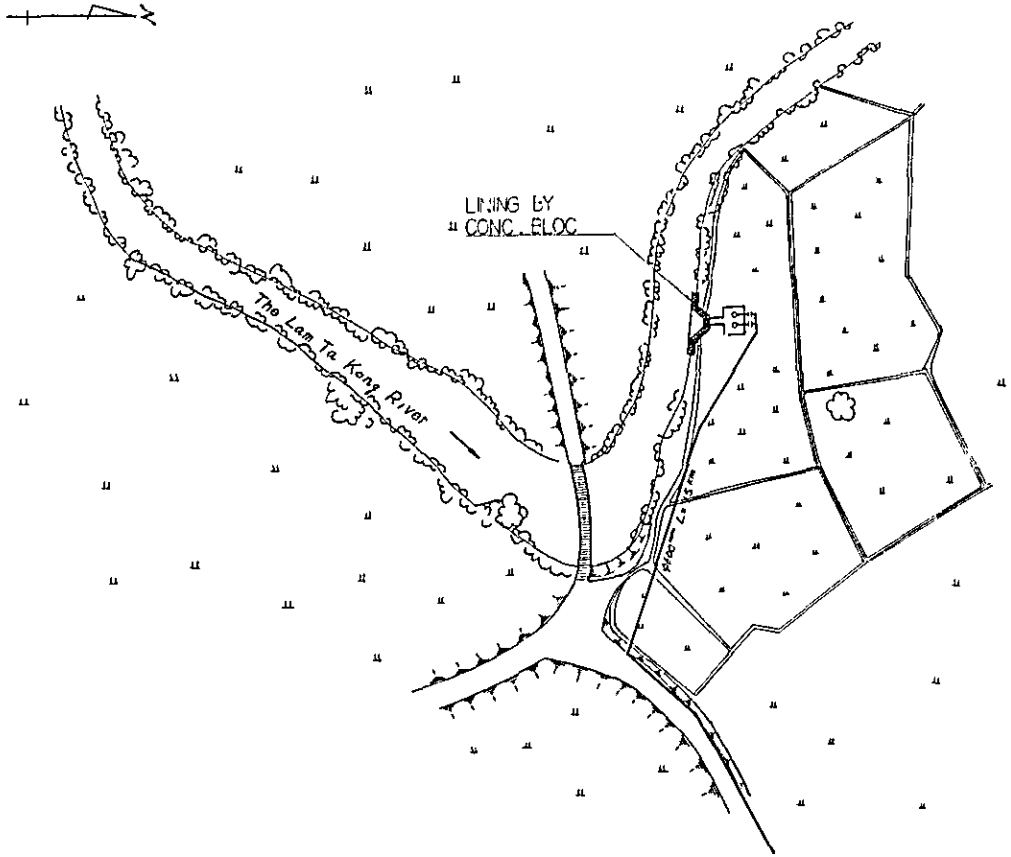
Item	Unit	Total cost	Imported equipments	Domestic equipments
Chemical Feeder	4 sets	880,000	-	880,000
Flash-mixer	4 sets	110,000	100,000	10,000
Baffle walls	10 sets	580,000	140,000	440,000
Filter bed	258 m^2	370,000	330,000	40,000
Flow controller (250 mm)	20 ch	500,000	494,600	5,400
Filter medium	258 m^2	103,200	-	103,200
Tester of Residual chlorine	2 sets	2,000	2,000	0
Miscellaneous	1 set	254,800	33,400	221,400
Sub Total		2,800,000	1,100,000	1,700,000

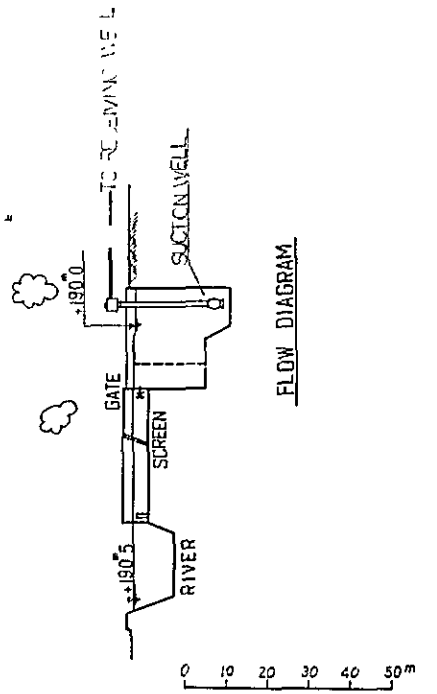
II. Investigation of Leakage (Unit : Baht)

Item	Unit	Total cost	Foreign currency	Local currency
Flight & Staying cost for technicians team	7 persons 85 days	750,000	750,000	-
Preparation & Report work in Japan		350,000	350,000	-
Lending machinery		1,100,000	1,100,000	-
Sub total		2,200,000	2,200,000	-
Grand Total		5,000,000	3,300,000	1,700,000

A professional team shall be invited, and they shall make an investigation of leakage and a leakage-proof construction in the model area, about 1 mile square, which are set in the served area. By this training, they shall learn the practice of investigation of leakage and a leakage-proof construction.

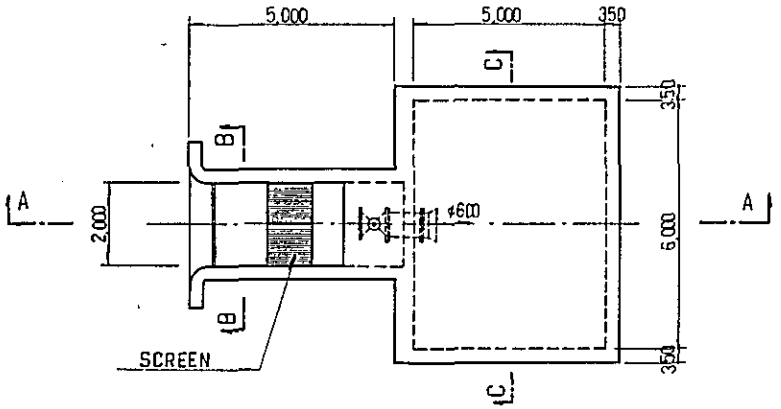
NAKHON RAJASHIMA WATER INTAKE AT BAN OUA



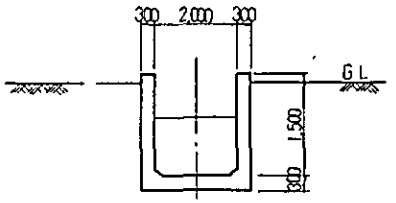


FLOW DIAGRAM

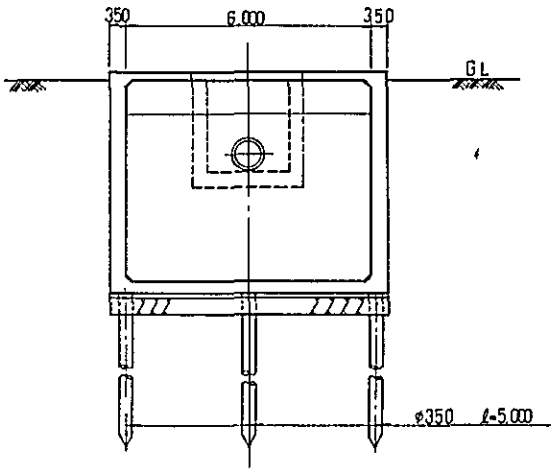
NAKHON RAJASIMA CITY WATER WORKS	DRWG NO. 1/10
INTAKE & GRIT CHAMBER	SCALE 1:1000
	UNIT m.



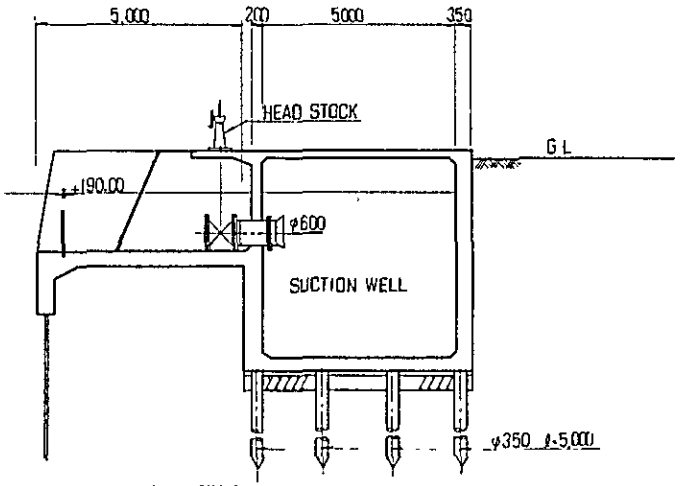
PLAN S-1:100



B-B SECTION



C-C SECTION



A-A SECTION S-1:100

0 1 2 3 4 5 m

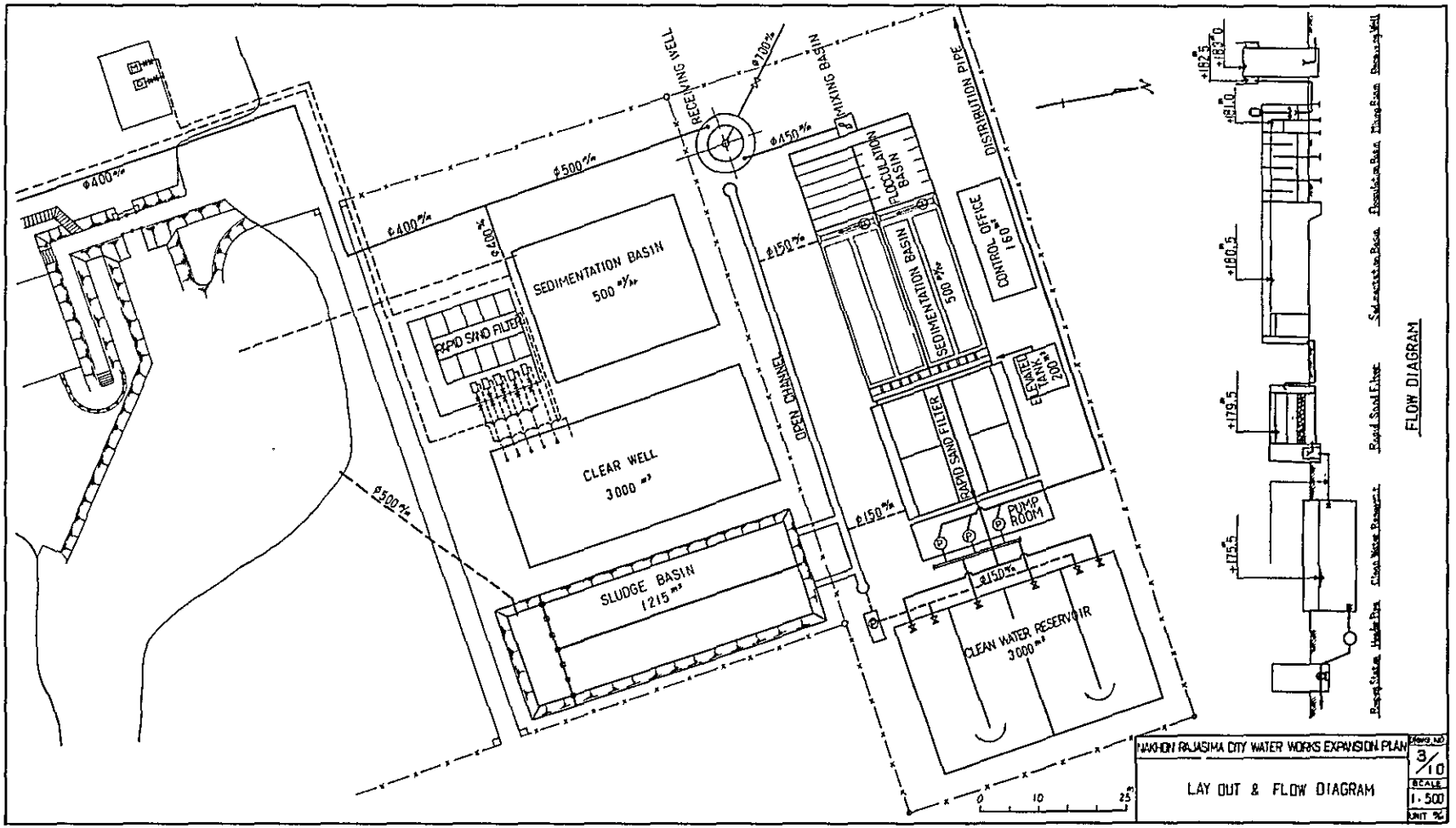
NAKHON RAJASIMA CITY WATER WORKS

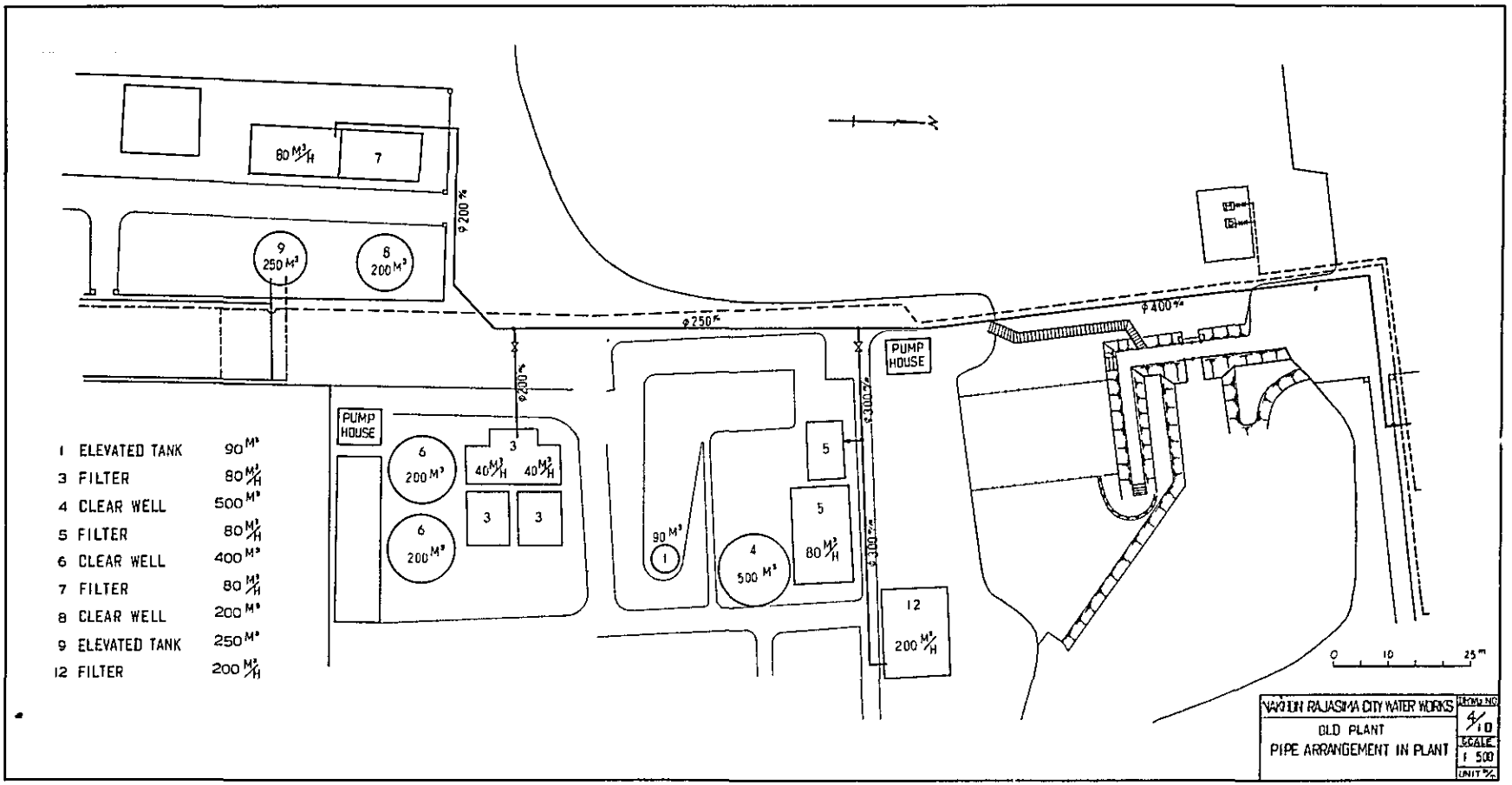
INTAKE CHANNEL

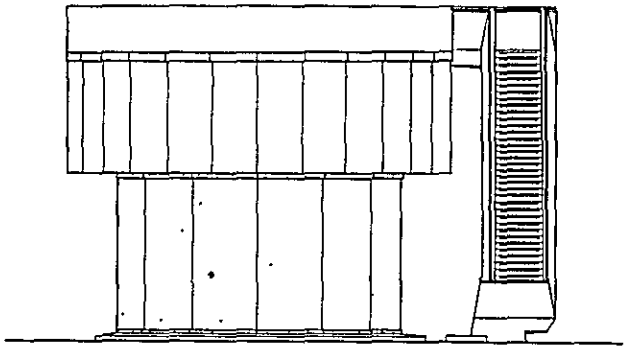
DRWG NO. 2/10

SCALE 1:100

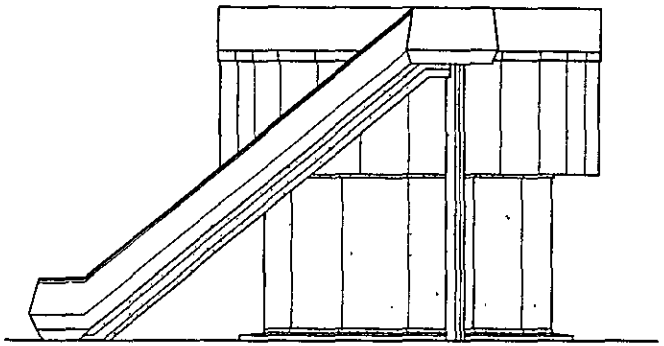
UNIT m


RECEIVING WELL
MIXING BASIN
DISTRIBUTION PIPE
FLOCULATION BASIN
SEDIMENTATION BASIN
500 m³/h
RAPID SAND FILTER
CLEAR WELL
3000 m³
SLUDGE BASIN
1215 m³
OPEN CHANNEL
CONTROL-OFFICE
160 m²
ELEVATED TANK
200 m³
PUMP ROOM
CLEAN WATER RESERVOIR
3000 m³
FLOW DIAGRAM
Pump Station
Intake Pipe
Clear Water Reservoir
Rapid Sand Filter
Sedimentation Basin
Flocculation Basin
Receiving Well
JAKHON RAJASIMA CITY WATER WORKS EXPANSION PLAN
LAY OUT & FLOW DIAGRAM
Drawing NO.
3/10
SCALE
1:500
UNIT M

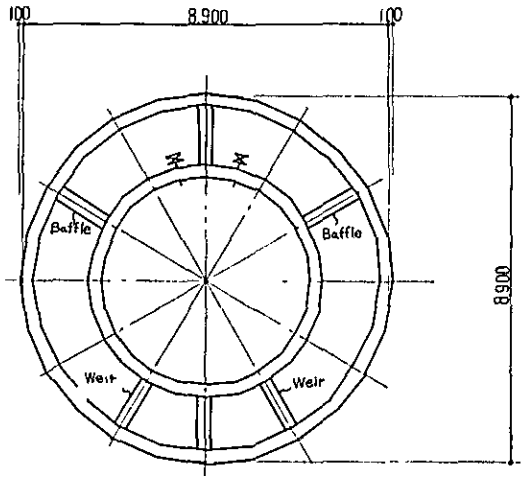

80 M³/H
7
9
250 M³
8
200 M³
φ 200 %
φ 250 %
φ 400 %
φ 200 %
φ 300 %
φ 300 %
PUMP HOUSE
PUMP HOUSE
6
200 M³
6
200 M³
3
40 M³/H
40 M³/H
3
3
90 M³
1
4
500 M³
5
5
80 M³/H
12
200 M³/H
1 ELEVATED TANK 90 M³
3 FILTER 80 M³/H
4 CLEAR WELL 500 M³
5 FILTER 80 M³/H
6 CLEAR WELL 400 M³
7 FILTER 80 M³/H
8 CLEAR WELL 200 M³
9 ELEVATED TANK 250 M³
12 FILTER 200 M³/H
0 10 25 m
YAKUIN RAJASIMA CITY WATER WORKS
OLD PLANT
PIPE ARRANGEMENT IN PLANT
DRWG NO 4/10
SCALE 1 500
UNIT m



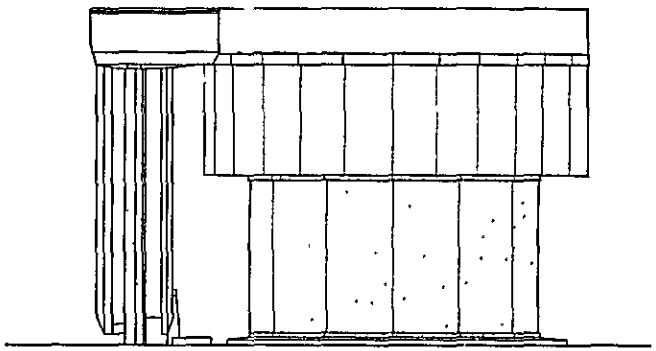
EAST ELEVATION S=1:100



NORTH ELEVATION S=1:100



ROOF S=1:100



SOUTH ELEVATION S=1:100

0 1 2 3 4 5m

NAKHON RAJASIMA CITY WATER WORKS

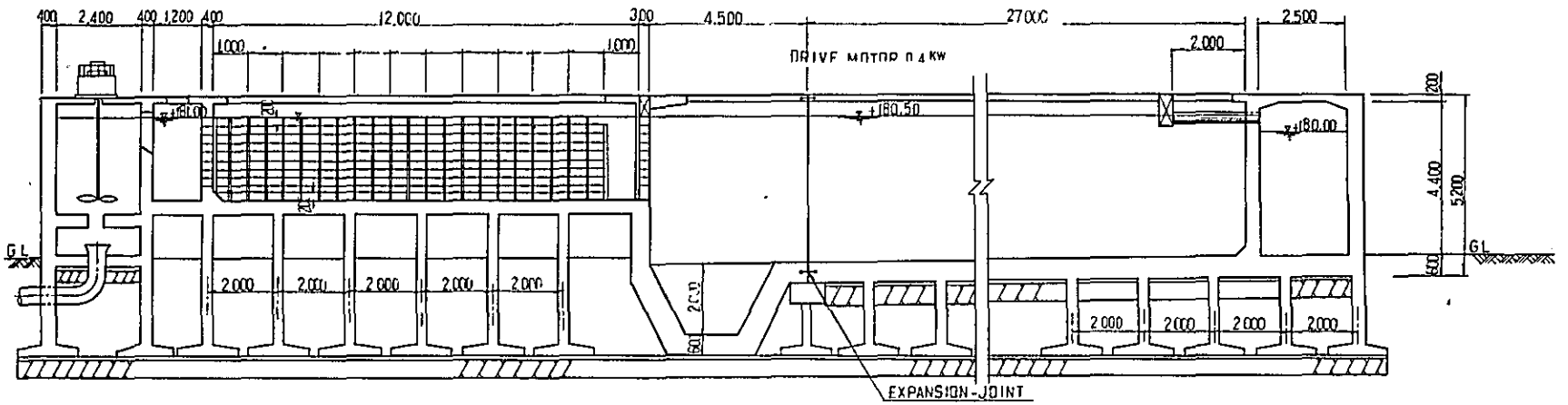
NEW TREATMENT PLANT

RECEIVING WELL

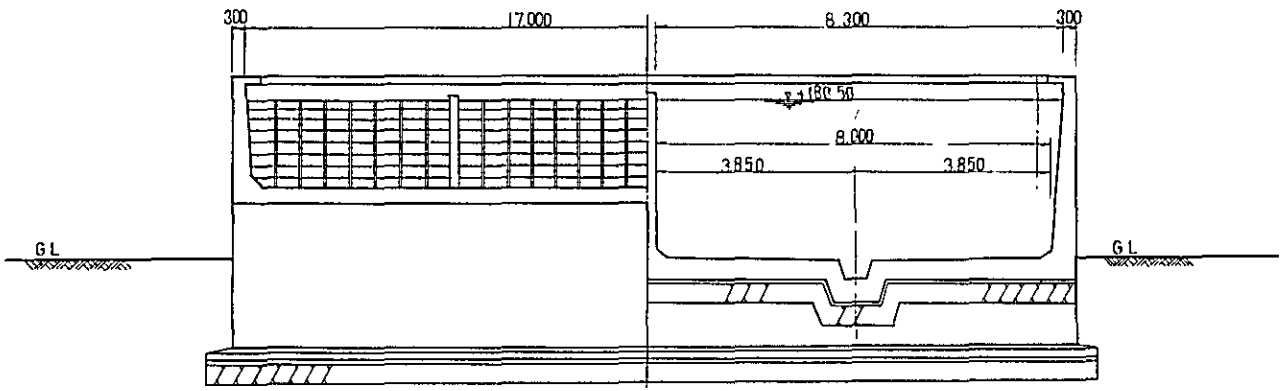
DRWG NO 5/10

SCALE 1:100

UNIT m



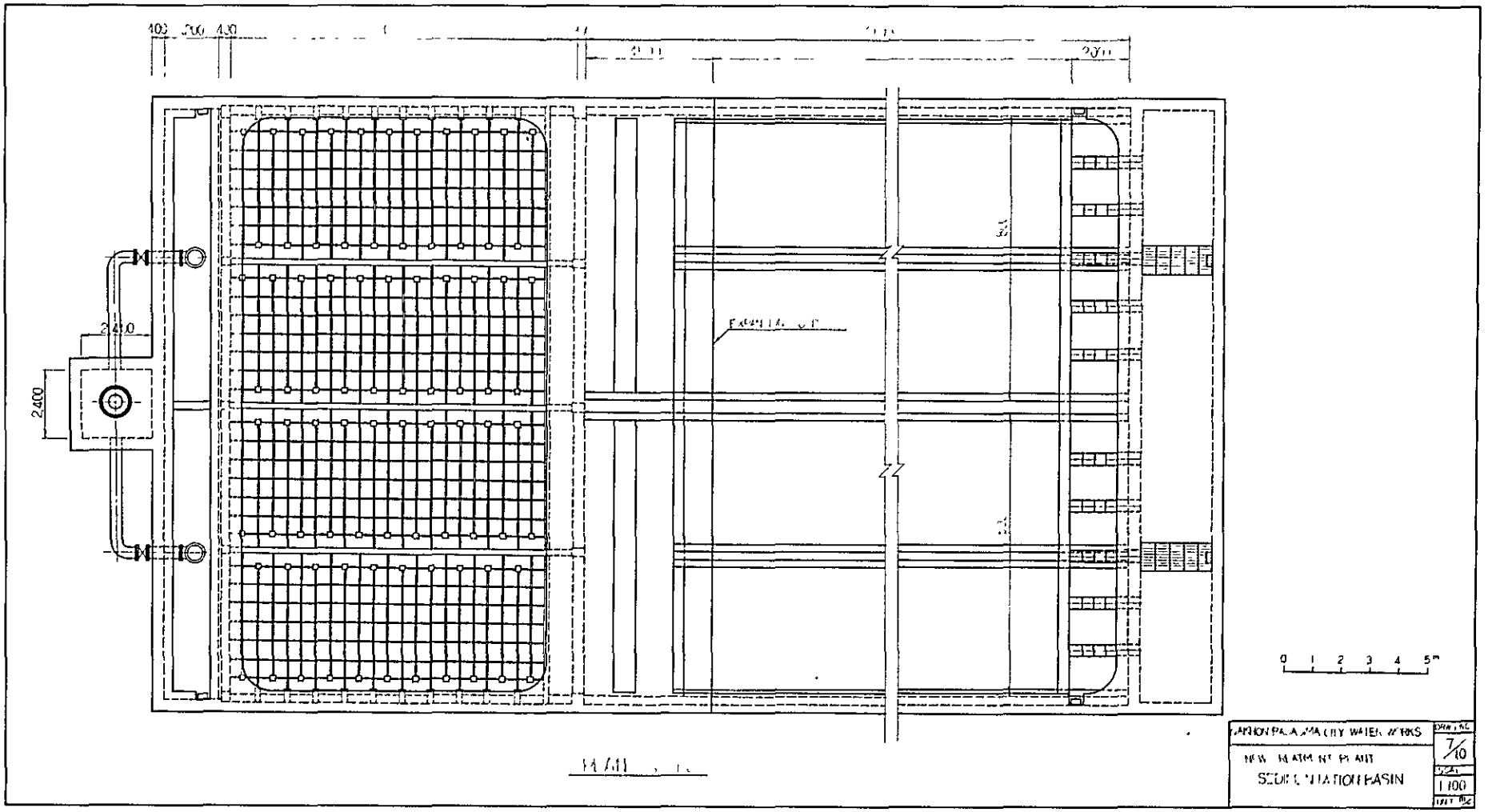
SECTION S=1:100



SECTION S=1:100

0 1 2 3 4 5m

NAKHON RAJASIMA CITY WATER WORKS	DRWG.NO 6/10
NEW TREATMENT PLANT	SCALE 1:100
SEDIMENTATION BASIN	UNIT m



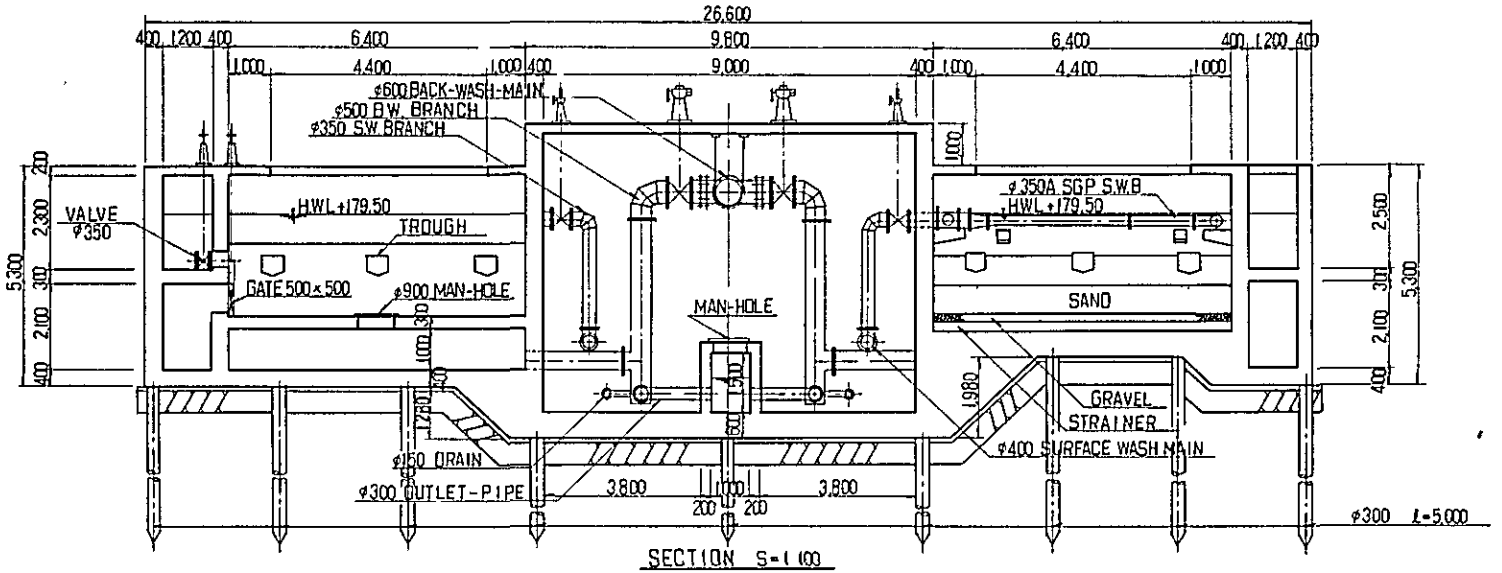
LAPU-LAPU CITY WATER WORKS

NEW TREATMENT PLANT

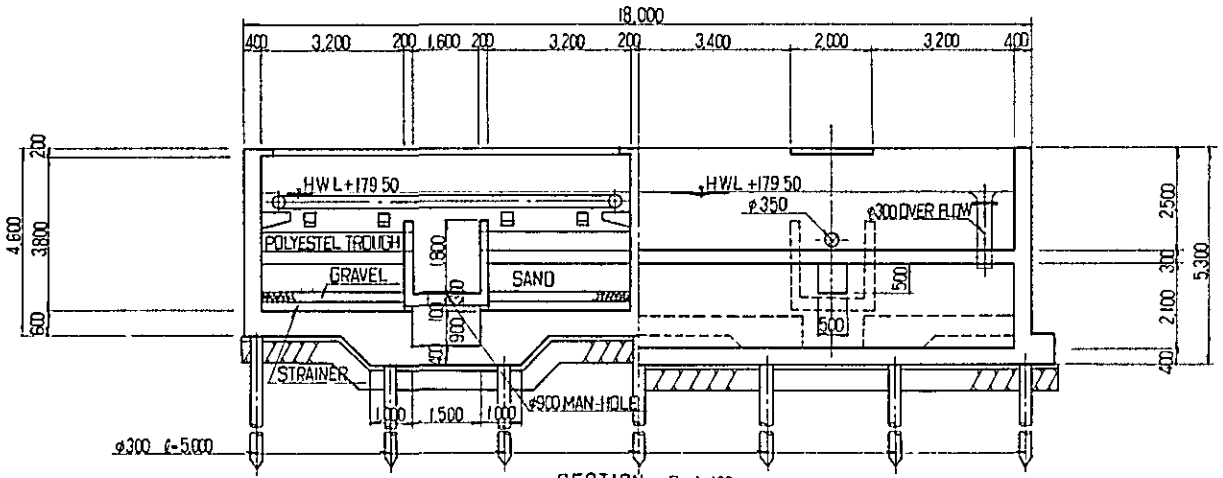
SEDIMENTATION BASIN

DRAWING NO. 7/10

SCALE 1:100



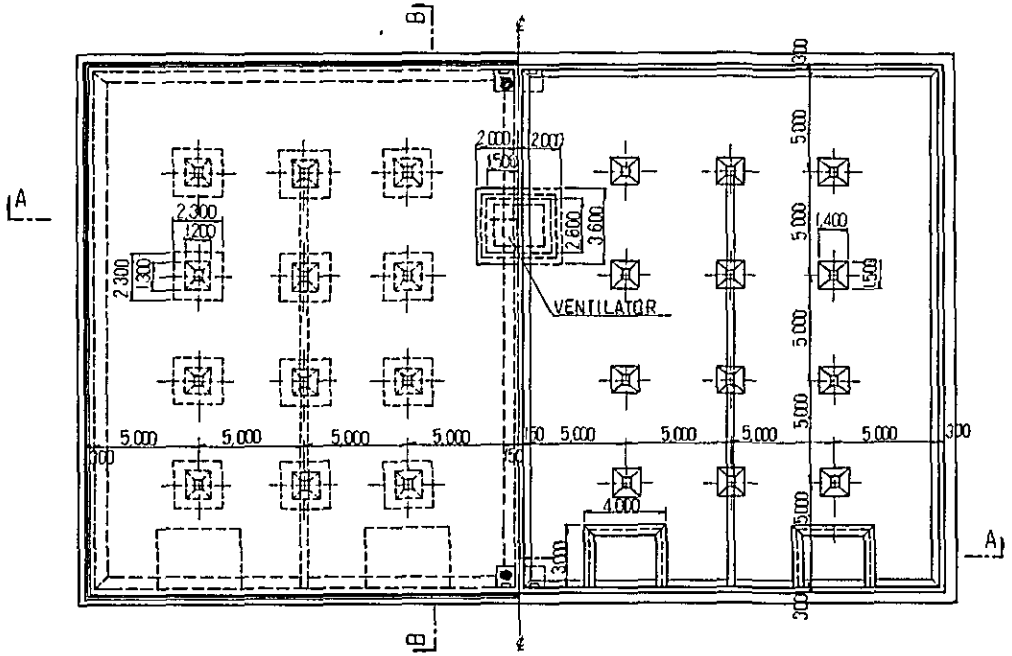
SECTION S=1:100



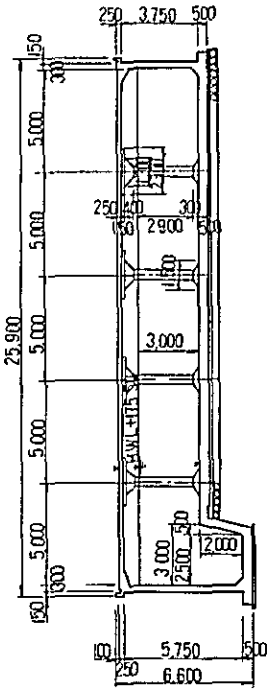
SECTION S=1:100

0 1 2 3 4 5 m

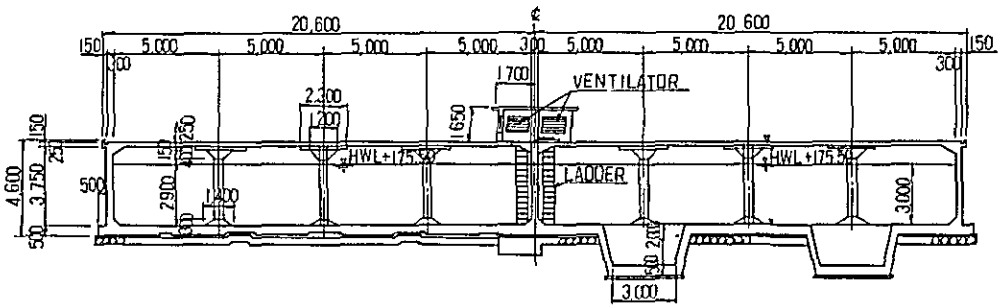
NAKHON RAJASIMA CITY WATER WORKS	DRWG.NO 8/10
NEW TREATMENT PLANT RAPID SAND FILTER	SCALE 1:100
	UNIT m



PLAN S=1:200



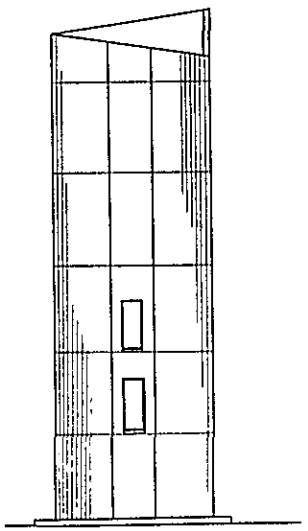
B-B SECTION S=1:200



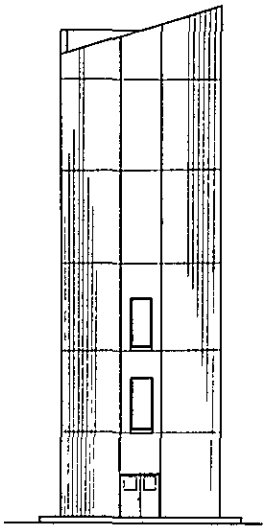
A-A SECTION S=1:200

0 5 10m

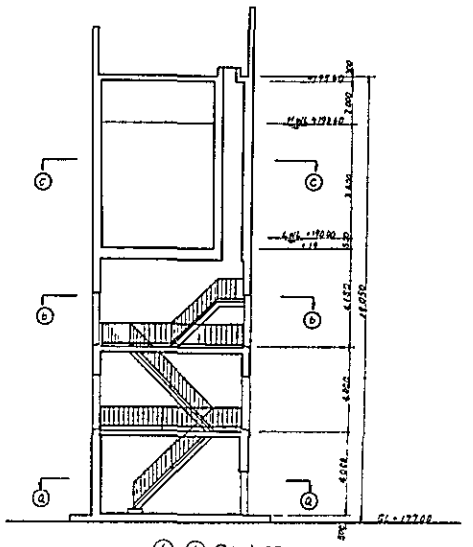
NAKHON RAJASIMA CITY WATER WORKS	DRWG NO. 9/10
CLEAN WATER RESERVOIR	SCALE 1:200
	UNIT m



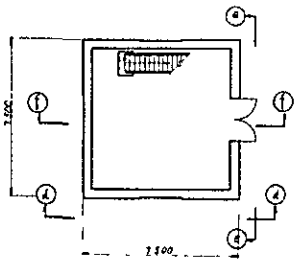
ⓓ-ⓓ Section



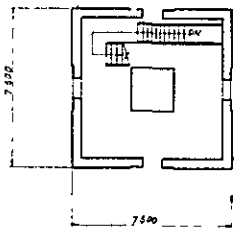
ⓔ-ⓔ Section



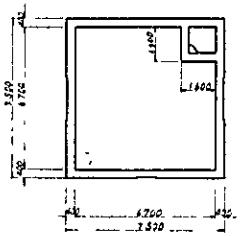
ⓕ-ⓕ Section



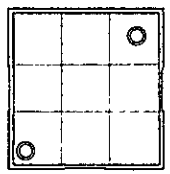
ⓐ ⓐ Plan



ⓑ-ⓑ Plan



ⓒ-ⓒ Plan



Roof Plan

0 5 10m

NAKHONRAJASIMA W WORKS

BACKWASHING

ELEVATED TANK

DRWG No. 10/10

SCALE 1:200

UNIT m/m

A P P E N D I X

Example of Automatic Filter

Greem;eaf Filter

Type: Greenleaf filter 8-cell type gravity sand filter

Basin: Reinforced concrete structure

Filtration Area: 115.62 m^2/cell

Filtration Velocity

Average:	120.0 m/D
Maximum:	150.0 m/D

Control Center

Inlet Siphon:	8 sets
Wash Siphon:	8 sets
Vacuum Tank:	2 sets
Effluent Weir:	1 set

Filter Bed

PS Concrete Plate:	1 lot
Strainer:	1 lot
Sand:	77 m^3
Gravel:	26 m^3

Vacuum Pump

Nash type Vacuum Pump:	2 sets
Capacity:	1.35 m^3/min
Pressure:	400 mmHg
Motor:	2.2 Kw, 380 v, 50 Hz totally-enclosed fancooled type outdoor service electric motor

Surface Wash Pump

Horizontal-shaft Volute Pump:	2 sets
Capacity:	2.0 m^3/min
Head:	24 m

Motor:	15 kw, 380 v, 50 Hz, totally-enclosed fancooled type outdoor service electric Motor

Surface Washer

Fixed-type Surface Washer with Nozzles:	1 set

Attachments

Wash Trough:	8 sets
400 mm sluice valve for cell partition:	4 sets
100 mm sluice valve for drain:	5 sets
450 mm wash pipe:	1 set
Vacuum Valve and Piping:	1 set
Air Piping:	1 set
0.75 kw air compressor:	2 sets
Filter Control Unit:	1 set

Comparison between Standard & Automatic Filters

Standard Type		Automatic type	
1. Construction Cost 4 sets (1 spare)		2 sets	
Civil Engineering Work		Civil Engineering Work	750,000
Rapid Filter 180 m^2	1,200,000	120 m^2	
		Machine	800,000
Electric Equipment, Machinery, Piping, & Filter Media	900,000	Electric	400,000
		Piping & Valves	850,000
Gallery	279,000	Filter Media	40,000
Elevated Tank	1,000,000	Packing & Inland Freight	120,000
Total	3,379,000 Baht	Total	2,960,000 Baht

2. Operating Cost (Annual)

Electric Power (Estimated) for Washing.

$q = 8.80\ m^3/min$ $H = 20\ m$

$q = 26.40\ m^3/min$ $H = 20\ m$

$$Ps = \frac{35.20 \times 0.163 \times 20}{0.75} = 15.3kw$$

$P = 15.3 \times 1.1 = 16,8 \quad 19\ kw$

4 chamber's operating time 40 min

$19\ kw \times \frac{40}{60} = 12.67\ kwH$

$0.7^{Baht} \times 12.67 \times 365 = 3,237^{Baht}$

Vaccum Pump 2 sets (1 spare)

$2.2kw \quad 0.35m^3/min = 21m^3/hour$

Surface Wash pump 2 sets (1 spare)

$15kw \quad 2.0m^3/min = 120m^3/hour$

$2.2kw \times 8^{hours} = 17.6\ kwh$

$15kw \times 8\ cell \times \frac{10}{60} min = 20kwH$

8 cell's operating time 80 min

$0.7 \times 37.6 \times 365 = 9,606$ Baht

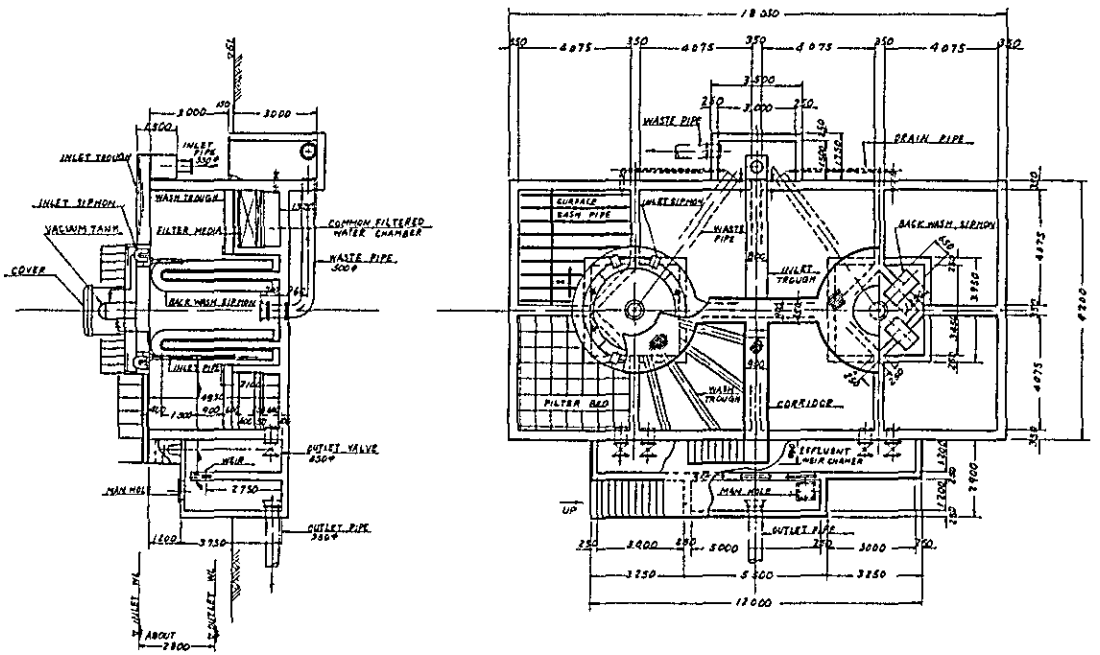
3. Maintenance Cost

Workers: 3 — Worker: 1

Salary $540 \times 3 \times 12 = 19,440$ Baht — $540 \times 1 \times 12 = 6,480$ Baht

Initial Cost: $3,379,000 - 2,960,000 = 419,000$ Baht

Running Cost: $(19,440 + 3,237) - (6,480 + 9,606) = 6,591$ Baht



NAMTHONRAJASIMA W WORKS	DRWG No.
GREENLEAF FILTER	SCALE 1:160
	UNIT m/m