5-4 Brief Outline of Alternative Plans

5-4-1 Right Bank :

(1) Case 1R :

The water sources of Case 1R will consist of wells in the 3 northern Amphoes, and surface water in Amphoe Nong Khaem and adjacent development area Bang Khun Thian. This plan will be relatively easy to implement as the 3 northern districts are to be supplied by wells.

On the other hand, the water supply for Nong Khaem and Bang Khun Thian will born a relatively considerable cost for transmission line as water will have to be carried from a distant river intake on account of the intrusion of sea water into the Nakhon Chai Si river. Baside of this problem, this water source seems satisfactory with respect to either quality or quantity of water.

The treatment plant should be located at Sathani Sala Ya which is located at about a midpoint between the water intake and the district of Nong Khaem, and treated water will be conveyed from there to the Amphoe Nong Khaem.

To supply the adjacent development area of Bang Khun Thian, a dedicated pump will be installed at Nong Khaem pump station to pump water into a executive pipe to carry water to the service reservoir.

(2) Case 2R:

The basic condition is made in Case 2R that the entire right bank area (where demand is placed at 56,400 CMD) is supplied with surface water and that the river intake and treatment plant is located the same as in Case 1R. In Case 2R, water will be carried from the treatment plant to the service reservoirs of the 3 northern districts (where demand is placed at 11,100 CMD) and that of Nong Khaem (45,300 CMD), and water will be transported by booster pumps and pipes to supply the respective communities.

Water will be carried from the treatment plant to the service reservoir of Nong Khaem in the same way as in Case 1R. But, supply to the 3 northern districts seems to pose problems : one is that a relatively small amount of water must be carried over a long distance; another is that it is difficult to supply Amphoe town as early as it desired; and, additionally, a system must be established to manage the water supply over a wide area, as the entire served area of this case will be covered by a single supply system.

(3) Case 3R :

Case 3R is a plan to supply the entire right bank area with water taken from the Klong Mae Nam Om. In this case a treatment plant will be located at the same site of the intake. This plan, relatively speaking, favors the supply to the 3 northern districts, but the route length of the transmission line to the district of Nong Khaem will be longer than in Case 1R, and a system to manage the water supply over a wide area will be required as in Case 2R.

(4) Case 4R :

In this case, the 3 northern districts will be supplied with water taken from wells as in Case 1R, and the districts of Nong Khaem and Bang Khun Thian will receive water from Tha Phra service reservoir of the central system.

This plan is advantageous in that it is as easy to implement as in the plan of Case 1R. Furthermore, diversion of water from the central system is very economical. However, this plan will be influenced by the construction schedule of the central system and may require revision depending on the result of a review of the capacity of the separate system. On account of these restraints, it is difficult to plan the water supply project independent of other factors.

(5) Case 5R :

In this case, the Klong Mae Nam Om will be tapped as in Case 3R to supply the 3 northern districts and a treatment plant will be built at the same site of the intake.

As the 3 northern districts together form an area of convenient size, it permits planning of an integrated water supply system. Accordingly, the supply for this area can be stablized and systematically managed.

Nong Khaem and Bang Khun Thian will be supplied with water diverted from the central system as in Case 4R.

(6) Case 6R :

Case 6R represents a plan to supply the entire served area with water diverted from the central system. The 3 northern districts will be supplied with water taken from Phra Ram Hok service reservoir of the central system and a booster pumping station will be installed in each district to supply the Amphoes. The water supply for this served area has one problem in that a relatively small amount of water will have to be carried over a long distance. On the other hand, the supply for Nong Khaem and Bang Khun Thian will be as economically advantageous as in Case 4R. This case has the same problems as Case 4R concerning the construction schedule of the central system and the capacity of the separate system which may be changed depending on the result of its review. Therefore, the implementation of the plan of this case is subject to a review of the plan of the central system.

5-4-2 Left Bank :

(1) Case 1L :

Case 1L represents a plan to supply 5 Amphoes and Bang Chan with groundwater and all the adjacent development area with surface water taken from the Klong. This plan will be as easy to carry out, as in Case 1R, as the Amphoes will be supplied with ground water.

On the other hand, the adjacent development area will be supplied with 161,350 CMD of water obtained from the Klong Sam Wa and Sip Sam. Water will be carried from the two intakes to a treatment plant which will be located near the Amphoe Town of Min Buri.

This plan to separately supply the Amphoes and the adjacent development area may be disadvantageous from a geographical point of view, but the project for supplying the Amphoes with ground water will be relatively easy to implement.

(2) Case 2L :

Case 2L assumes that the entire left bank area will be supplied with water taken from the Klong. As the water supply in this case depends on the Klong to the greatest extent of all cases, the treatment plant will have to be built on the largest scale (212,500 CMD) accordingly. The water source will be the same as that of Case 1L, and the location of the intake and treatment plant will also be the same as for Case 1L.

As the entire served area is planned to be supplied with surface water, it will be difficult to supply Amphoe Town as early as it is desired, but the plan of Case 1L can be modified to suit this case. At any rate, the supply for this area can be stabilized and systematically managed as an integrated supply system from intake to distribution.

(3) Case 3L :

Case 3L assumes that 5 Amphoes and Bang Chan will be supplied with groundwater, the eastern adjacent development area with surface water taken from the Klong and the southern adjacent development area with water diverted from the central system.

The supply for the Amphoes is planned as in Case 1L. Water taken from the Klong Sam Wa will be carried to a treatment plant to be located near Amphoe Town of Min Buri. Water to be diverted from the central system will be taken from the service reservoir of Samrong and conveyed to Bang Phli and Bang Bo, and Bang Poo and Klong Dan through separate pipes.

As it is planned in this case to use the water source nearest each district to be served, water will be taken from the largest number of sources of all the alternative cases and there will be little mutual relationship among the served districts.

(4) Case 4L :

Case 4L is a plan to supply 3 eastern districts and the eastern adjacent development area with surface water taken from the Klong, and 2 southern districts and the southern adjacent development area with water diverted from the central system.

This plan is much like Case 3L so that it can be modified to suit Case 3L. But, under this plan the served area is divided into two parts from a geographic point of view.

Surface water will be taken from the Klong Sam Wa alone, while water to be diverted from the central system will be received from Sam Rong service reservoir. Otherwise, the basic concept of water supply is the same as that for Case 3L.

(5) Case 5L :

Case 5L represents a plan to supply 5 Amphoes and Bang Chan with groundwater, and all the adjacent development area with water diverted from the central system.

The plan to depend on wells to supply the Amphoes is the same as in Case 1L. Water to be diverted from the central system will be received from Pak Bo and Sam Rong service reservoirs. Water will have to be carried over a considerable distance from the central system to the respective districts, but this plan will be economically advantages in part because no treatment plant will be needed and the administration and maintenance of the supply system will be simple.

(6) Case 6L :

In Case 6L it is assumed that the entire left bank area will be supplied with water diverted from the central system, taking water from Bang Thong Lang, Pak Bo and Sam Rong service reservoirs.

As the supply system of this case will depend on the central system for all its supply of water, its plan will also rest with the construction schedule of the central system so that independent planning in this case will be impossible, the same as was noted for Case 6R.

5-5 Basic Construction Cost and Scale of Facilities

5-5-1 Basic for Estimation :

The basic construction cost for comprehensive water supply was estimated based upon the data collected by M.W.W.A., and the costs of major import items, such as pumps, machinery, electric apparatus, instruments and pipes (D.C.I.P.) were estimated based upon the Japanese market prices plus ocean freight, import duties, etc.

In the case where water is assumed to be diverted from the central system, the basic construction cost was estimated based on the following assumptions :

1) The scope of estimation is limitted to the equipment and facilities from the system to the pumping station built near the central system service reservoir.

2) The additional expanses by increasing the capacities of pumps is excluded from the scope of estimation.

3) The cost of distribution piping and facilities works is not included in the basic construction cost in the Adjacent Industrial and/or Residential Areas.

The basic construction cost estimated in this Sec. do not include the cost escalation and land cost.

The rough estimations of the basic construction costs for the alternative cases are shown in Table 5-3, and their breakdowns by water source are shown in Tables 5-4 and 5-5.

Table 5-3 SUMMARY OF BASIC CONSTRUCTION COST

CASE		BASIC CONSTRUCTION COST (₱)	GRADE
RIGHT BANK	1	735,302,000	D
	2	873,660,000	E
	3	882,309,000	F
	4	406,936,000	A
	5	489,372,000	C
	6	481,017,000	B
LEFT BANK	1	1,761,384,000	E
	2	1,908,000,000	F
	3	956,415,000	C
	4	1,059,751,000	D
	5	847,725,000	A
	6	920,800,000	B

(1) Right Bank

Table 5-4 SUMMARY OF BASIC CONSTRUCTION COST PER CMD

Case	District	Water Source	Water Demand (CMD)	Basic Construction Cost (฿)	฿/CMD
1	North 3 Districts	Well	11,100	123,847,000	11,157
	Nong Khaem District	River	45,300	611,455,000	13,498
	Total		56,400	735,302,000	13,037
2	All Right Bank	River	56,400	873,660,000	15,490
3	All Right Bank	Klong	56,400	882,309,000	15,643
4	North 3 Districts	Well	11,100	123,847,000	11,157
	Nong Khaem District	Central	45,300	283,089,000	6,249
	Total		56,400	406,936,000	7,215
5	North 3 District	Klong	11,100	206,283,000	18,584
	Nong Khaem District	Central	45,300	283,089,000	6,249
	Total		56,400	489,372,000	8,677
6	All Right Bank	Central	56,400	481,017,000	8,529

(2) Left Bank

Table 5-5 SUMMARY OF BASIC CONSTRUCTION COST PER CMD

Case	District	Water Source	Water Demand (CMD)	Basic Construction Cost (฿)	฿/CMD
1	All Amphoes & Bang Chan	Well	31,800	236,254,000	7,429
	East & South Developments	Klong x 2	161,350	1,525,130,000	9,452
	Total		193,150	1,761,384,000	9,119
2	All Left Bank	Klong x 2	193,150	1,908,000,000	9,878
3	All Amphoes & Bang Chan	Well	31,800	236,254,000	7,429
	East Developments	Klong	51,350	356,110,000	6,935
	South Developments	Central	110,000	364,051,000	3,310
	Total		193,150	956,415,000	4,952
4	East 3 Districts & Developments	Klong	77,350	626,282,000	8,097
	South 2 District & Developments	Central	115,800	433,469,000	3,743
	Total		193,150	1,059,751,000	5,487
5	All Amphoes & Bang Chan	Well	31,800	236,254,000	7,429
	East & South Developments	Central	161,350	611,471,000	3,790
	Total		193,150	847,725,000	4,389
6	All Left Bank	Central	193,150	920,800,000	4,767

5-5-2 Scale of Main Facilities and Breakdown of Basic Construction Cost:

The scale of main facilities and the breakdown of construction cost by water sources and service area blocks for all alternative cases are shown in Tables 5-6 to 5-17. The water sources are classified into as follows :

1) Groundwater (Well)

2) Surface water (Klong and river).

3) Water diverted from the central system.

The basic construction cost of the distribution system was estimated for only the 9 Amphoes and for the adjacent development area, but the cost of laying pipe beyond the service reservoir built in each area is not included in the estimation.

Each estimation of basic construction cost includes a 20% allowance for miscellaneous expenses.

(1 (1) Right Bank

Table 5-6 (R) CASE - 1

SURFACE WATER : NAKHON CHAI SI RIVER (UNIT, 1000 B)

DESCRIPTION \ SERVED AREA			NORTH 3 DISTRICTS (AMPHOE) SAI NOI	BANG BUA THONG	BANG YAI	NONG KHAEM	DEVELOPMENT PROGRAM BANG KHUN THIAN	COST
WELL			$Q = 1,000\ m^3/d$ x 1 unit $Q = 500\ m^3/d$ x 1 unit	$Q = 1,500\ m^3/d$ x 2 units $Q = 1,100\ m^3/d$ x 2 units	*$Q = 1,200\ m^3/d$ x 1 unit $Q = 1,000\ m^3/d$ x 1 unit $Q = 1,100\ m^3/d$ x 2 units	-		26,092
SURFACE WATER	INTAKE	QUANTITY	-			$Q = 49,800\ m^3/d$		
		PUMP				ø300 x $11.53m^3$/min x 42m x 114kw x 2 sets ø250 x 5.76 m^3/min x 42m x 60kw x 4 sets		14,667
	RAW WATER MAIN		-			DCIP ø700 L = 12.0 km		80,796
	TREATMENT PLANT		-			$Q = 49,800\ m^3/d$		
	TRANSMISSION	PUMP	-			ø300 x ø250 x $10.49m^3$/min x 39m x 96kw x 2sets ø200 x ø150 x $5.24m^3$/min x 39m x 52kw x 4 sets		243,412
		BOOSTER PUMP	-			ø100 x $1.84m^3$/min x 50m x 25kw x 3 sets		4,000
		PIPE	-			DCIP ø700 L = 13.0 km DCIP ø300 L = 14.5 km		112,722
CENTRAL SYSTEM			-			-		-
DISTRIBUTION	SERVICE RESERVOIR		$V = 520\ m^3$	$V = 1,860\ m^3$	$V = 1,520\ m^3$	$V = 14,240\ m^3$	-	
	DISTRIBUTION PUMP		-			6 sets		
	LIFTING PUMP		3 sets	4 sets	4 sets	-		
	ELEVATED TANK		$V = 100\ m^3$	*$V = 50\ m^3$	*$V = 60\ m^3$	-		
	BOOSTER PUMP		3 units	6 units	5 units	-		
	PIPE		ø100 - ø150 L = 22.0 km	ø100 - ø400 L = 58.85 km	ø100 - ø250 L = 38.4 km	ø100 - ø700 L = 79.09 km		253.613
COST (1,000 B)			20,294	61,366	42,187	611,455		735,302

* EXISTING

Table 5-7 (R) CASE - 2

SURFACE WATER : NAKHON CHAI SI RIVER

(UNIT 1,000 ฿)

DESCRIPTION \ SERVED AREA	NORTH 3 DISTRICTS (AMPHOE): SAI NOI	NORTH 3 DISTRICTS (AMPHOE): BANG BUA THONG	NORTH 3 DISTRICTS (AMPHOE): BANG YAI	NONG KHAEM	DEVELOPMENT PROGRAM BANG KHUN THIAN	COST
WELL	-					-
SURFACE WATER – INTAKE – QUANTITY	$Q = 62,000\ m^3/d$					
SURFACE WATER – INTAKE – PUMP	ϕ300 x 10,764 m^3/min x 37 m x 94 kw x 5 sets					15,208
SURFACE WATER – RAW WATER MAIN	DCIP ϕ800 L = 12.0 km					99,084
SURFACE WATER – TREATMENT PLANT	$Q = 62,000\ m^3/d$					
SURFACE WATER – TRANSMISSION – PUMP	ϕ300 x ϕ250 x 10.49 m^3/min x 39m x 96kw x 2 sets ϕ200 x ϕ150 x 5.24 m^3/min x 39m x 52kw x 4 sets			ϕ100 x 2.08m^3/min x 49m x 28kw x 3 sets ϕ100 x 1.77m^3/min x 49m x 24kw x 2 sets		291,712
SURFACE WATER – TRANSMISSION – BOOSTER PUMP	ϕ100 x 1.55m^3/min x 50m x 23kw x 4 sets ϕ 80 x 0.52m^3/min x 39m x 7.5kw x 3 sets			ϕ100 x 1.84m^3/min x 50m x 25kw x 3 sets		10,847
SURFACE WATER – TRANSMISSION – PIPE	DCIP ϕ400 L = 14.0 km DCIP ϕ300 L = 9.5 km DCIP ϕ200 L = 15.0 km			DCIP ϕ700 L = 13.0 km DCIP ϕ300 L = 14.5 km		203,196
CENTRAL SYSTEM	-					-
DISTRIBUTION – SERVICE RESERVOIR	$V = 520\ m^3$	$V = 1,860\ m^3$	$V = 1,520\ m^3$	$V = 14,240\ m^3$	-	
DISTRIBUTION – DISTRIBUTION PUMP	-			6 set		
DISTRIBUTION – LIFTING PUMP	3 sets	4 sets	4 sets	-		
DISTRIBUTION – ELEVATED TANK	$V = 100\ m^3$	$*V = 50\ m^3$	$*V = 60\ m^3$	-		
DISTRIBUTION – BOOSTER PUMP	3 units	6 units	5 units	-		
DISTRIBUTION – PIPE	ϕ100 - ϕ150 L = 22.0 km	ϕ100 - ϕ400 L = 58.85 km	ϕ100 - ϕ250 L = 38.4 km	ϕ100 - ϕ700 L = 79.09 km		253,613
COST (1,000 ฿)	-					873,660

* EXISTING

Table 5-8 (R) CASE - 3

SURFACE WATER : KLONG MAE NAM OM
(UNIT 1,000 ฿)

DESCRIPTION \ SERVED AREA			NORTH 3 DISTRICTS (AMPHOE): SAI NOI	NORTH 3 DISTRICTS (AMPHOE): BANG BUA THONG	NORTH 3 DISTRICTS (AMPHOE): BANG YAI	NONG KHAEM	DEVELOPMENT PROGRAM BANG KHUM THIAN	COST
WELL			-					-
SURFACE WATER	INTAKE	QUANTITY	$Q = 62,000\ m^3/d$					
		PUMP	ϕ300 x 10.764 m^3/min x 10 m x 25 kw x 5 sets					
	RAW WATER MAIN		-					
	TREATMENT PLANT		$Q = 62,000\ m^3/d$					
	TRANSMISSION	PUMP	ϕ300 x ϕ200 x 11.5 m^3/min x 46 m x 124 kw x 2 sets ϕ250 x ϕ150 x 5.75 m3/min x 46 m x 67 kw x 4 sets			ϕ100 x 1.55m^3/min x 30m x 14kw x 4 sets		304,313
		BOOSTER PUMP	ϕ300 x ϕ250 x 10.49 m3/min x 39 m x 96 kw x 2 sets ϕ200 x ϕ150 x 5.24 m3/min x 39 m x 52 kw x 4 sets			ϕ100 x 1.84m^3/min x 50m x 25kw x 3 sets ϕ 80 x 0.52m3/min x 39 m x 7.5kw x 3sets		35,699
		PIPE	DCIP ϕ800 L = 4.5 km DCIP ϕ700 L = 14.0 km DCIP ϕ300 L = 5.0 km		DCIP ϕ700 L = 13.0 km DCIP ϕ300 L = 14.5 km DCIP ϕ200 L = 15.0 km			288,684
CENTRAL SYSTEM			-					-
DISTRIBUTION	SERVICE RESERVOIR		$V = 520\ m^3$	$V = 1,860\ m^3$	$V = 1,520\ m^3$	$V = 14,240\ m^3$	-	
	DISTRIBUTION PUMP		-			6 sets		
	LIFTING PUMP		3 sets	4 sets	4 sets	-		
	ELEVATED TANK		$V = 100\ m^3$	$*V = 50\ m^3$	$*V = 60\ m^3$	-		
	BOOSTER PUMP		3 units	6 units	5 units	-		
	PIPE		ϕ100 - ϕ150 L = 22.0 km	ϕ100 - ϕ400 L = 58.85 km	ϕ100 - ϕ250 L = 38.4 km	ϕ100 - ϕ700 L = 79.09 km		253,613
COST (1,000 ฿)			-					882,309

* EXISTING

Table 5-9 (R) CASE - 4

CENTRAL SYSTEM : THA PHRA RESERVOIR

(UNIT 1,000 ฿)

DESCRIPTION \ SERVED AREA		NORTH 3 DISTRICTS (AMPHOE)			NONG KHAEM	DEVELOPMENT PROGRAM BANG KHUM THIAN	COST
		SAI NOI	BANG BUA THONG	BANG YAI			
WELL		Q = 1,000 m^3/d x 1 unit Q = 500 m^3/d x 1 unit	Q = 1,500 m^3/d x 2 units Q = 1,100 m^3/d x 2 units	*Q = 1,200 m^3/d x 1 unit Q = 1,000 m^3/d x 1 unit Q = 1,100 m^3/d x 2 units	-	-	26,092
SURFACE WATER		-	-	-	-	-	-
CENTRAL SYSTEM	PUMP	-	-	-	Q = 45,300 m^3/d ϕ250 x ϕ200 x 7.9m^3/min x 35m x 70kw x 5sets		28,327
	PIPE	-	-	-	DCIP ϕ700 L = 13.2 km DCIP ϕ300 L = 7.6 km		98,904
DISTRIBUTION	SERVICE RESERVOIR	V = 520 m^3	V = 1,860 m^3	V = 1,520 m^3	V = 14,240 m^3	-	
	DISTRIBUTION PUMP	-	-	-	6 sets	-	
	LIFTING PUMP	3 sets	4 sets	4 sets	-	-	
	ELEVATED TANK	V = 100 m^3	*V = 50 m^3	*V = 60 m^3	-	-	
	BOOSTER PUMP	3 units	6 units	5 units	-	-	
	PIPE	ϕ100 - ϕ150 L = 22.0 km	ϕ100 - ϕ400 L = 58.85 km	ϕ100 - ϕ250 L = 38.4 km	ϕ100 - ϕ700 L = 79.09 km	-	253,613
COST (1,000 ฿)		20,294	61,366	42,187	283,089		406,936

* EXISTING

Table 5-10 (R) CASE - 5

SURFACE WATER : KLONG MAE NAM OM
CENTRAL SYSTEM : THA PHRA RESERVOIR

(UNIT 1,000 ฿)

DESCRIPTION			NORTH 3 DISTRICTS (AMPHOE): SAI NOI	NORTH 3 DISTRICTS (AMPHOE): BANG BUA THONG	NORTH 3 DISTRICTS (AMPHOE): BANG YAI	NONG KHAEM	DEVELOPMENT PROGRAM BANG KHUN THIAN	COST
WELL			-			-		-
SURFACE WATER	INTAKE	QUANTITY	Q = 12,200 m^3/d			-		
		PUMP	ϕ200 x 2.82 m^3/min x 10 m x 8 kw x 4 sets					
	RAW WATER MAIN		-			-		
	TREATMENT PLANT		Q = 12,200 m^3/d			-		
	TRANSMISSION	PUMP	ϕ100 x 1.55m^3/min x 30 m x 14 kw x 3 sets ϕ100 x 1.53m^3/min x 17 m x 7.5 kw x 4 sets					62,669
		BOOSTER PUMP	ϕ 80 x 0.52m^3/min x 39 m x 7.5 kw x 3 sets			-		2,749
		PIPE	DCIP ϕ300 L = 9.5 km DCIP ϕ200 L = 15.0 km			-		43,110
CENTRAL SYSTEM	PUMP		-			Q = 45,300 m^3/d ϕ250xϕ200x7.9m^3/min x 35m x 70kw x 5sets		28,327
	PIPE		-			DCIP ϕ700 L = 13.2 km DCIP ϕ300 L = 7.6 km		98,904
DISTRIBUTION	SERVICE RESERVOIR		V = 520 m^3	V = 1,860 m^3	V = 1,520 m^3	V = 14,240 m^3	-	
	DISTRIBUTION PUMP		-			6 sets		
	LIFTING PUMP		3 sets	4 sets	4 sets	-		
	ELEVATED TANK		V = 100 m^3	*V = 50 m^3	*V = 60 m^3	-		
	BOOSTER PUMP		3 units	6 units	5 units	-		
	PIPE		ϕ100 - ϕ150 L = 22.0 km	ϕ100 - ϕ400 L = 58.85 km	ϕ100 - ϕ250 L = 38.4 km	ϕ100 - ϕ700 L = 79.09 km		253,613
COST (1,000 ฿)			206,283			283,089		489,372

* EXISTING

Table 5-11 (R) CASE - 6

CENTRAL SYSTEM : PHRA RAM HOK & THA PHRA RESERVOIR

(UNIT 1,000 ฿)

DESCRIPTION \ SERVED AREA		NORTH 3 DISTRICTS (AMPHOE)			NONG KHAEM	DEVELOPMENT PROGRAM BANG KHUN THIAN	COST
		SAI NOI	BANG BUA THONG	BANG YAI			
WELL		-					-
SURFACE WATER		-					-
CENTRAL SYSTEM	PUMP	Q = 11,100 m^3/d ϕ100 x 2.08 m^3/min x 50 m x 30 kw x 3 sets ϕ100 x 1.77 m^3/min x 50 m x 30 kw x 2 sets ϕ 80 x 0.52 m^3/min x 39 m x 7.5 kw x 3 sets			Q = 45,300 m^3/d ϕ250 x ϕ200 x 7.9 m^3/min x 35m x 75 kw x 5 sets		50,312
	PIPE	DCIP ϕ400 L = 13.4 km DCIP ϕ300 L = 1.6 km DCIP ϕ200 L = 15.0 km			DCIP ϕ700 L = 13.2 km DCIP ϕ300 L = 7.6 km		177,092
DISTRIBUTION	SERVICE RESERVOIR	V = 520 m^3	V = 1,860 m^3	V = 1,520 m^3	V = 14,240 m^3	-	
	DISTRIBUTION PUMP	-			6 sets		
	LIFTING PUMP	3 sets	4 sets	4 sets	-		
	ELEVATED TANK	V = 100 m^3	*V = 50 m^3	*V = 60 m^3	-		
	BOOSTER PUMP	3 units	6 units	5 units	-		
	PIPE	ϕ100 - ϕ150 L = 22.0 km	ϕ100 - ϕ400 L = 58.85 km	ϕ100 - ϕ250 L = 38.4 km	ϕ100 - ϕ700 L = 79.09 km		253,613
COST (1,000 ฿)		197,928			283,089		481,017

* EXISTING

(2) Left Bank

Table 5-12 (L) CASE - 1

SURFACE WATER : KLONG SAM WA & SIP SAM

(UNIT 1,000 ฿)

DISCRIPTION / SERVED AREA			EAST 3 DISTRICTS (AMPHOE) NONG CHOK	MIN BURI	LAT KRABANG	SOUTH 2 DISTRICTS (AMPHOE) BANG PHLI	BANG BO	EAST DEVELOPMENT PROGRAM	SOUTH DEVELOPMENT PROGRAM	COST
WELL			Q = 945 m^3/d x 2 units Q = 870 m^3/d x 3 units	Q = 1,460 m^3/d x 5 units	Q = 1,520m^3/d x 4 units Q = 1,510m^3/d x 2 units	Q = 1,400m^3/d x 2 units	*Q = 1,200m^3/d x 1 unit oQ = 1,000m^3/d x 1 unit Q = 1,000m^3/d x 2 units	Bang Chan Q = 1,275m^3/d x 4 units	—	74,354
SURFACE WATER	INTAKE	QUANTITY	-					Q_1=94,400m^3/d	Q_2=83,100m^3/d	
SURFACE WATER	INTAKE	PUMP	-					ϕ400 x 16.4m^3/min x 13m x 55 kw x 5 sets ϕ400 x 14.5m^3/min x 48m x 200 kw x 5 sets		65,300
SURFACE WATER	RAW WATER MAIN		-					DCIP ϕ1,000 L = 1.5 km DCIP ϕ 900 L = 19.0 km		183,700
SURFACE WATER	TREATMENT PLANT		-					Q = 177,500 m^3/d		
SURFACE WATER	TRANSMISSION	PUMP	-					ϕ400 x 28.1m^3/min x 25m x 190 kw x 5 sets		548,660
SURFACE WATER	TRANSMISSION	BOOSTER PUMP	-					ϕ400 x 21.5 x 40 x 220 x 5 ϕ450 x 25.5 x 25 x 150 x 4 ϕ400 x 20.0 x 27 x 150 x 4 ϕ200 x 4.8 x 25 x 30 x 4		118,700
SURFACE WATER	TRANSMISSION	PIPE	-					DCIP ϕ1,200 L = 7.2km, ϕ1,100 L = 4.0km DCIP ϕ1,100 L = 15.0km, ϕ 900 L = 10.3km DCIP ϕ 800 L = 5.3km, ϕ 700 L = 1.6km DCIP ϕ 600 L = 10.2km, ϕ 500 L = 11.2km DCIP ϕ 400 L = 9.4km, ϕ 300 L = 3.0km		608,770
CENTRAL SYSTEM			-					-		-
DISTRIBUTION	SERVICE RESERVOIR		V = 1,520 m^3	V = 2,560 m^3	V = 3,040 m^3	V = 1,000 m^3	V = 1,000 m^3	-		161,900
DISTRIBUTION	LIFTING PUMP		5 sets	5 sets	5 sets	4 sets	4 sets			
DISTRIBUTION	ELEVATED TANK		*V = 60 m^3	*V =50m^3,70m^3	*V =50m^3,60m^3	*V = 100 m^3	*V=100m^3,120m^3			
DISTRIBUTION	BOOSTER PUMP		3 units	7 units	6 units	2 units	1 unit			
DISTRIBUTION	PIPE		ACP ϕ300 - ϕ100 = 33.05 km	DCIP ϕ400 ACP ϕ300 - ϕ100 L = 44.2 km	DCIP ϕ400 ACP ϕ300 - ϕ100 L = 57.95 km	ACP ϕ200 - ϕ100 L = 26.15 km	ACP ϕ200 - ϕ100 L = 15.1 km			
COST (1,000 ฿)			40,549	60,458	72,451	27,990	20,282	1,539,654		1,761,384

* EXISTING
o EXISTING NEW WELL

Table 5-13 (L) CASE - 2

SURFACE WATER : KLONG SAM WA & SIP SAM
(UNIT 1,000 ฿)

DESCRIPTION / SERVED AREA			EAST 3 DISTRICTS (AMPHOE): NONG CHOK	EAST 3 DISTRICTS (AMPHOE): MIN BURI	EAST 3 DISTRICTS (AMPHOE): LAT KRABANG	SOUTH 2 DISTRICTS (AMPHOE): BANG PHLI	SOUTH 2 DISTRICTS (AMPHOE): BANG BO	EAST DEVELOPMENT PROGRAM	SOUTH DEVELOPMENT PROGRAM	COST
WELL			-					-		
SURFACE WATER	INTAKE	QUANTITY	Q_1 = 112,500 m^3/d, Q_2 = 100,000 m^3/d							
SURFACE WATER	INTAKE	PUMP	ø400 x 19.6m^3/min x 12 m x 60 kw x 5 sets			ø400 x 17.4 m^3/min x 42 m x 200 kw x 5 set				74,500
SURFACE WATER	RAW WATER MAIN		DCIP ø1,100 L = 1.5 km, DCIP ø1,000 L = 19.0 km							222,800
SURFACE WATER	TREATMENT PLANT		Q = 212,500 m^3/d							
SURFACE WATER	TRANSMISSION	PUMP	ø400 x 30.6 m^3/min x 27 m x 220 kw x 5 sets ø125 x 2.8 x 10 x 11 x 4			ø100 x 1.8 x 27 x 15 x 3				637,700
SURFACE WATER	TRANSMISSION	BOOSTER PUMP	ø450 x 24.0 x 50 x 300 x 5 ø125 x 1.6 x 48 x 22 x 3			ø350 x 15.0 x 25 x 95 x 5 ø200 x 4.8 x 25 x 30 x 4 ø125 x 1.1 x 50 x 15 x 3				117,600
SURFACE WATER	TRANSMISSION	PIPE	DCIP ø1,200 L = 7.2 km " ø1,100 L = 19.0 km " ø 900 L = 10.3 km		DCIP ø800 L = 5.3 km " ø700 L = 1.6 km " ø600 L =10.2 km		DCIP ø500 L = 14.8 km " ø400 L = 5.9 km " ø300 L = 25.9 km " ø200 L = 5.4 km			693,500
CENTRAL SYSTEM			-							-
DISTRIBUTION	SERVICE RESERVOIR		V = 1,520 m^3	V = 2,560 m^3	V = 3,040 m^3	V = 1,000 m^3	V = 1,000 m^3	-		161,900
DISTRIBUTION	LIFTING PUMP		5 sets	5 sets	5 sets	4 sets	4 sets			
DISTRIBUTION	ELEVATED TANK		*V = 60 m^3	*V = 50m^3,70m^3	*V = 50m^3,60m^3	*V = 100 m^3	*V = 100m^3,120m^3			
DISTRIBUTION	BOOSTER PUMP		3 units	7 units	6 units	2 units	1 unit			
DISTRIBUTION	PIPE		ACPø300 - ø100 L = 33.05 km	DCIP ø400 ACPø300 - ø100 L = 44.2 km	DCIP ø400 ACPø300 - ø100 L = 57.95 km	ACPø200 - ø100 L = 26.15 km	ACP ø200 - ø100 L = 15.1 km			
COST (1,000 ฿)			-							1,908,000

* EXISTING

Table 5-14 (L) CASE - 3

SURFACE WATER : KLONG SAM WA
CENTRAL SYSTEM : SAMRONG RESERVOIR

(UNIT 1,000 ฿)

DESCRIPTION \ SERVED AREA			EAST 3 DISTRICTS (AMPHOE): NONG CHOK	EAST 3 DISTRICTS (AMPHOE): MIN BURI	EAST 3 DISTRICTS (AMPHOE): LAT KRABANG	SOUTH 2 DISTRICTS (AMPHOE): BANG PHLI	SOUTH 2 DISTRICTS (AMPHOE): BANG BO	EAST DEVELOPMENT PROGRAM	SOUTH DEVELOPMENT PROGRAM	COST
WELL			Q = 945 m^3/d x 2 units Q = 870 m^3/d	Q = 1,460m^3/d x 5 units	Q = 1,520m^3/d x 4 units Q = 1,510m^3/d x 2 units	Q = 1,400 m^3/d x 2 units	*Q = 1,200 m^3/d x 1 unit oQ = 1,000m^3/d x 1 unit Q = 1,000m^3/d x 2 units	Bang Chan Q = 1,275 m^3/d x 4 units	-	74,354
SURFACE WATER	INTAKE	QUANTITY	-					Q = 56,500m^3/d	-	
SURFACE WATER	INTAKE	PUMP	-					∅300x9.8m^3/min x15m x45kw x5sets	-	15,900
SURFACE WATER	RAW WATER MAIN		-					DCIP ∅800 L = 1.5 km		11,000
SURFACE WATER	TREATMENT PLANT		-					Q = 56,500m^3/d		
SURFACE WATER	TRANSMISSION	PUMP	-					∅300x19m^3/min x23m x75kw x4sets	-	210,860
SURFACE WATER	TRANSMISSION	BOOSTER PUMP	-					∅200x3.1x51x55x4		10,700
SURFACE WATER	TRANSMISSION	PIPE	-					DCIP ∅800 L=72km " ∅700 L=16km " ∅400 L=134km " ∅300 L=3.0km	-	170,650
CENTRAL SYSTEM	PUMP		-					-	Q=110,000m^3/d ∅350x19.1m^3/min x35m x170kw x 5 sets ∅250x7.2m^3/min x 50m x90kw x3sets	55,051
CENTRAL SYSTEM	PIPE		-					-	DCIP ∅900 L=15.0km ∅600 L=23.0km ∅500 L=16.5km	309,000
DISTRIBUTION	SERVICE RESERVOIR		V = 1,520m^3	V = 2,560m^3	V = 3,040m^3	V = 1,000m^3	V = 1,000m^3	-	-	161,900
DISTRIBUTION	LIFTING PUMP		5 sets	5 sets	5 sets	4 sets	4 sets			
DISTRIBUTION	ELEVATED TANK		*V = 60 m^3	*V=50m^3,70m^3	*V=50m^3,60m^3	*V = 100m^3	*V = 100m^3,120m^3			
DISTRIBUTION	BOOSTER PUMP		3 units	7 units	6 units	2 units	1 unit			
DISTRIBUTION	PIPE		ACP ∅300 - ∅100 L = 33.05 km	DCIP ∅400 ACP ∅300 - 100 L = 44.2 km	DCIP ∅400 ACP ∅300 - ∅100 L = 57.95 km	ACP ∅200 - ∅100 L = 26.15km	ACP ∅200 - ∅100 L = 15.1 km			
COST (1,000 ฿)			40,549	60,458	72,451	27,990	20,282	370,634	364,051	954,415

* EXISTING
o EXISTING NEW WELL

Table 5-15 (L) CASE - 4

SURFACE WATER : KLONG SAM WA
CENTRAL SYSTEM : SAMRONG RESERVOIR
(UNIT 1,000 ฿)

DISCRIPTION \ SERVED AREA			EAST 3 DISTRICTS (AMPHOE) NONG CHOK	MIN BURI	LAT KRABANG	EAST DEVELOPMENT PROGRAM	SOUTH 2 DISTRICTS (AMPHOE) BANG PHLI	BANG BO	SOUTH DEVELOPMENT PROGRAM	COST
WELL			-				-			-
SURFACE WATER	INTAKE	QUANTITY	Q = 85,100 m^3/d				-			22,600
		PUMP	ϕ350 x 14.8 m^3/min x 15 m x 60 kw x 5 sets							
	RAW WATER MAIN		DCIP ϕ900 L = 1.5 km				-			13,300
	TREATMENT PLANT		Q = 35,100 m^3/d				-			284,300
	TRANSMISSION	PUMP	ϕ350 x 14.0 m^3/min x 27 m x 90 kw x 4 sets ϕ200 x 2.8 x 10 x 11 x 4 ϕ100 x 1.8 x 27 x 15 x 3							
		BOOSTER PUMP	ϕ250 x 5.2 x 35 x 55 x 3 ϕ200 x 3.5 x 28 x 26 x 3 ϕ100 x 1.6 x 43 x 22 x 3				-			23,500
		PIPE	DCIP ϕ800 L = 7.2 km ϕ400 L = 5.9 km ϕ700 L = 1.6 km ϕ300 L = 25.9 km ϕ500 L = 7.6 km				-			157,700
CENTRAL SYSTEM	PUMP		-				Q = 115,800 m^3/d ϕ350 x 20.1 m3/min x 35m x 180kw x 5 sets ϕ200 x 4.8 x 50 x 60 x 4 ϕ100 x 1.1 x 45 x 15 x 3			78,851
	PIPE		-				DCIP ϕ900 L = 15.0 km ϕ600 L = 23.0 km ϕ200 L = 6.4 km ϕ500 L = 16.0 km			317,600
DISTRIBUTION	SERVICE RESERVOIR		V = 1,520 m^3	V = 2,560 m^3	V = 3,040 m^3	-	V = 1,000 m^3	V = 1,000 m^3	-	161,900
	LIFTING PUMP		5 sets	5 sets	5 sets		4 sets	4 sets		
	ELEVATED TANK		*V = 60 m^3	*V = 50m^3, 70m^3	*V=50m^3, 60m^3		*V = 100 m^3	*V = 100m^3, 120m^3		
	BOOSTER PUMP		3 units	7 units	6 units		2 units	1 unit		
	PIPE		ACPϕ300 - ϕ100 L = 33.05 km	DCIP ϕ400 ACPϕ300 - ϕ100 L = 44.2 km	DCIP ϕ400 ACPϕ300 - ϕ100 L = 57.95 km		ACPϕ200 - ϕ100 L = 26.15 km	ACPϕ200 - ϕ100 L = 15.1 km		
COST (1,000 ฿)			626,282				433,469			1,059,751

* Existing

Table 5-16 (L) CASE - 5

CENTRAL SYSTEM : PAK BO & SAMRONG RESERVOIR
(UNIT 1,000 ฿)

SERVED AREA / DISCRIPTION		EAST 3 DISTRICTS (AMPHOE)			SOUTH 2 DISTRICTS (AMPHOE)		EAST DEVELOPMENT PROGRAM	SOUTH DEVELOPMENT PROGRAM	COST
		NONG CHOK	MIN BURI	LAT KRABANG	BANG PHLI	BANG BO			
WELL		Q = 945 m³/d x 2 units Q = 870 m³/d x 3 units	Q = 1,460 m³/d x 5 units	Q = 1,520m³/d x 4 units Q = 1,510m³/d x 2 units	Q = 1,400m³/d x 2 units	*Q = 1,200m³/d x 1 units oQ = 1,000m³/d x 1 units Q = 1,000m³/d x 2 units	Bang Chan Q = 1,275m³/d x 4 units	-	74,354
SURFACE WATER		-					-		-
CENTRAL SYSTEM	PUMP	-					Q_1= 51,350m³/d Q_2=110,000m³/d ϕ300x8.9m³/min x45m x100kw x5sets ϕ350x19.1 x35 x170 x5 ϕ250x7.2 x50 x 90 x3		85,173
	PIPE	-					DCIPϕ900 L=15.0km ϕ500 L=16.5km ϕ800 L=14.3km ϕ400 L= 9.4km ϕ700 L= 5.6km ϕ300 L= 3.0km ϕ600 L=23.0km		526,298
DISTRIBUTION	SERVICE RESERVOIR	V = 1,520 m³	V = 2,560 m³	V = 3,040 m³	V = 1,000 m³	V = 1,000 m³	-		161,900
	LIFTING PUMP	5 sets	5 sets	5 sets	4 sets	4 sets			
	ELEVATED TANK	*V = 60 m³	*V=50m³,70m³	*V=50m³,60m³	*V = 100 m³	*V=100m³,120m³			
	BOOSTER PUMP	3 units	7 units	6 units	2 units	1 unit			
	PIPE	ACP ϕ300 - ϕ100 L = 33.05 km	DCIP ϕ400 ACP ϕ300 - ϕ100 L = 44.2 km	DCIP ϕ400 ACP ϕ300 - ϕ100 L = 57.95 km	ACPϕ200 - ϕ100 L = 26.15 km	ACP ϕ200 - ϕ100 L = 15.1 km			
COST (1,000 ฿)		40,549	60,458	72,451	27,990	20,282	625,995		847,725

* EXISTING
o EXISTING NEW WELL

Table 5-17 (L) CASE - 6

CENTRAL SYSTEM : BANG THONG RANG, PAK BO & SAMRONG RESERVOIR
(UNIT 1,000 B)

DESCRIPTION \ SERVED AREA		EAST 3 DISTRICTS (AMPHOE)			SOUTH 2 DISTRICTS (AMPHOE)		EAST DEVELOPMENT PROGRAM	SOUTH DEVELOPMENT PROGRAM	COST
		NONG CHOK	MIN BURI	LAT KRABANG	BANG PHLI	BANG BO			
WELL		-							-
SURFACE WATER		-							-
CENTRAL SYSTEM	PUMP	Q_1 = 16,900 m^3/d Q_2 = 60,450 m^3/d Q_3 = 115,800 m^3/d ø200 x 4.0m3/min x 35m x 37kw x 4sets, ø200 x 4.4m3/min x 25m x 30kw x 4sets, ø100 x 1.1m3/min x 45m x 15kw x 3 sets ø350 x 14.0 x 48 x 190 x 4 ø350 x 20.1 x 35 x 180 x 5 ø200 x 2.8 x 28 x 22 x 4 ø200 x 4.8 x 50 x 60 x 4 ø100 x 1.6 x 43 x 22 x 3 ø250 x 6.2 x 30 x 45 x 4							150,900
	PIPE	DCIP ø900 L = 15.0 km ø500 L = 31.6 km ø800 L = 14.3 km ø400 L = 11.0 km ø700 L = 5.6 km ø300 L = 20.6 km ø600 L = 23.0 km ø200 L = 6.4 km							590,000
DISTRIBUTION	SERVICE RESERVOIR	V = 1,520 m^3	V = 2,560 m^3	V = 3,040 m^3	V = 1,000 m^3	V = 1,000 m^3	-		161,900
	LIFTING PUMP	5 sets	5 sets	5 sets	4 sets	4 sets			
	ELEVATED TANK	*V = 60 m^3	*V=50m^3,70m^3	*V=50m^3,60m^3	*V = 100 m^3	*V=100m^3,120m^3			
	BOOSTER PUMP	3 units	7 units	6 units	2 units	1 unit			
	PIPE	ACP ø300 - ø100 L = 33.05 km	DCIP ø400 ACP ø300 - ø100 L = 44.2 km	DCIP ø400 ACP ø300 - ø100 L = 57.95 km	ACP ø200 - ø100 L = 26.15 km	ACP ø200 - ø100 L = 15.1 km			
COST (1,000 B)		-							920,800

* EXISTING

5-6 Selection of Optimum Plan

It is quite difficult to select the most rational, both technically and economically, water supply plan from among the alternative cases described in Sec. 5-4, as each case still has problems to be solved. In the present study, however, an attempt will be made to choose the most optimum plan within the framework of the feasibility study of a separate system in consideration of the future socio-economic development of Thailand.

When all the alternative cases are reviewed, assuming that the water works are planned as the Greater Bangkok Area project, including both the central and separate systems, it would be ideal to take surface water from more than one source so as to assure a stable water supply. (Refer to right bank Case 2R and left bank Case 2L.)

However, the optimum feasible plan would be a case where the water works can be built at a minimum cost, when the economic conditions of the water supply project, the necessity of proper water supply management, the burden of increasing water charges on the community people and the present condition of the water authority are taken into consideration.

The combinations of the right or left bank and water sources are shown in Table 5-18 and Fig. 5-13 in order of increasing construction cost. Respective to the selection of water sources from the standpoint of construction cost, the following can be stated :

1) It would be economically advantageous to also depend on the wells for water, so long as the pumpage established according to the survey results is not exceeded.

2) The plan to divert water from the central system will be more economically advantageous than the plan to use surface water, as the water supply by the former plan will need no treatment plant.

3) The water supply system will be quite expensive to build, if surface water is to be utilized over a wide area. The use of

surface water should therefore be limited to an area of convenient size near the water intake point.

The major considerations which should be made in the use of each water source are noted as follows :

1) The use of wells should be allowed in only 8 Amphoes, excluding Nong Khaem, and in Bang Chan.

2) Phase 1 Project of the first stage of the central system is now under construction and the detail design of the Phase 2 Project has already been completed. The plan to divert water from the central system after Phase 2 Project must therefore be coped with its subsequent construction schedule.

3) Agreement must be reached with the authorities having jurisdiction concerning the water rights when the plan to use surface water is to be carried out.

4) The comprehensive water supply project which plans to depend on only surface water and build several water treatment plants does not seem feasible from an economic point of view, for its construction cost would be about 2.2 times as high as that of the least expensive plan. (Refer to right bank Cases 2R or 3R and left bank Case 2L.)

When the least expensive combinations of water sources are also taken into account in addition to the above considerations, the water supply projects in almost all existing Amphoes seem easy and relatively inexpensive, as they plan to dig wells. If wells are digged in the existing Amphoes, the other districts will be supplied by the central system. Tha Phra reservoir on the right bank is already under construction so that it can supply the Amphoes by the target year 1982. Furthermore, the detailed design of Khlong Toey reservoir has already been completed. When Pak Bo and Samrong reservoirs which will follow it,are built in the next stage of construction of the Bangkok water supply project, it will be possible to supply the adjacent development areas on the left bank in 1985.

As a conclusion, the optimum feasible plans which would be the least expensive of all alternative cases are recommended in this study as follows.

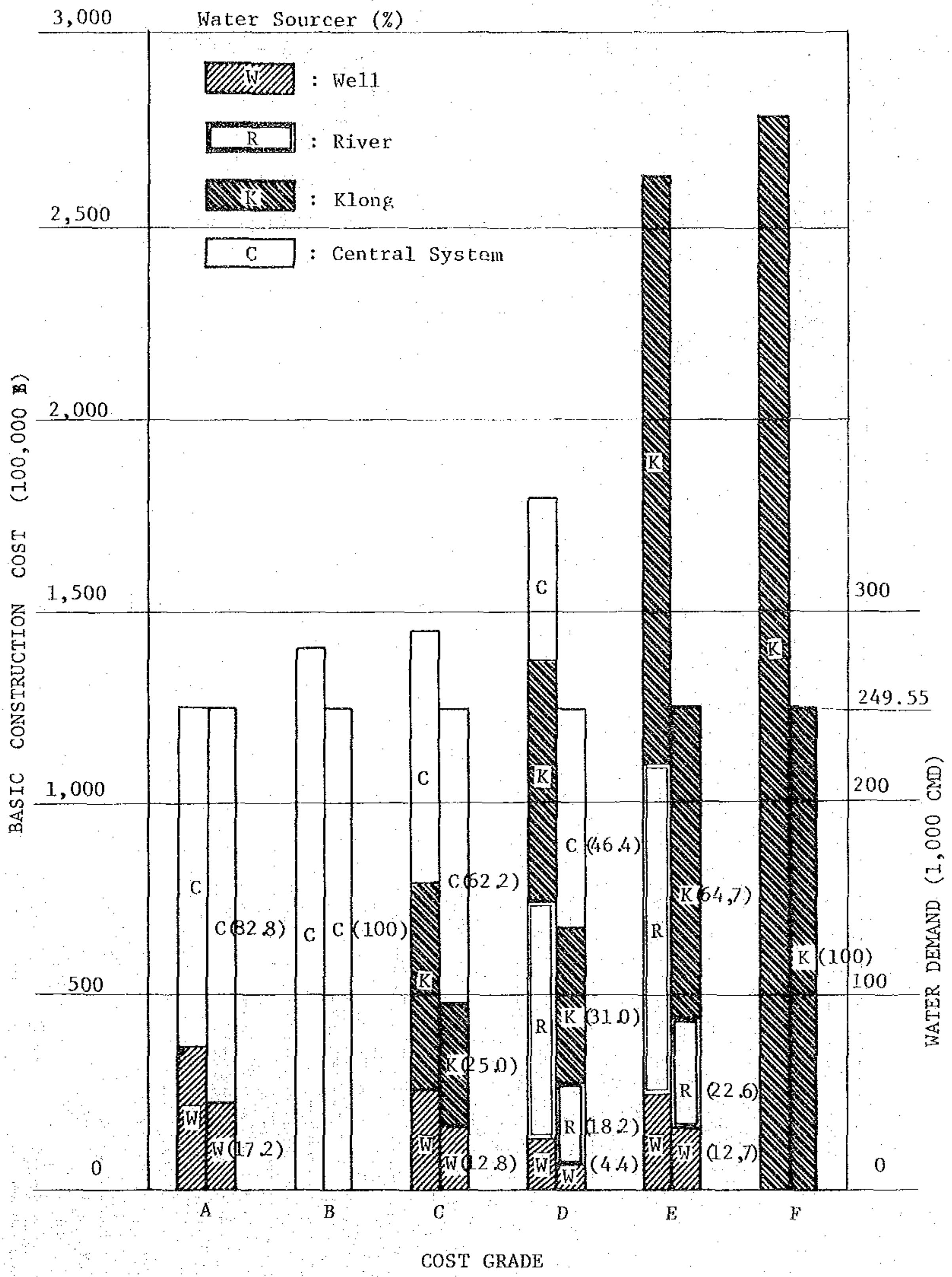
1) Right Bank : Case 4R

2) Left Bank : Case 5L

Table 5-18 TOTAL BASIC CONSTRUCTION COST OF SEPARATE SYSTEM

Grade	Case	Basic Construction Cost (1,000 ฿)	Cost (฿/CMD)	Per-centage (%)	Water Sources (CMD)							
					Well	(%)	River	(%)	Klong	(%)	Central	(%)
A	R - 4	406,936	7,215		11,100		-		-		45,300	
	L - 5	847,725	4,389		31,800		-		-		161,350	
	Total	1,254,661	5,004	100	42,900	17.2	-		-		206,650	82.8
B	R - 6	481,017	8,529		-		-		-		56,400	
	L - 6	920,800	4,767		-		-		-		193,150	
	Total	1,401,817	5,617	112	-		-		-		249,550	100
C	R - 5	489,372	8,677		-		-		11,100		45,300	
	L - 3	956,415	4,952		31,800		-		51,350		110,000	
	Total	1,445,787	5,794	115	31,800	12.8	-		62,450	25.0	155,300	62.2
D	R - 1	735,302	13,037		11,100		45,300		-		-	
	L - 4	1,059,751	5,487		-		-		77,350		115,800	
	Total	1,795,053	7,193	143	11,100	4.4	45,300	18.2	77,350	31.0	115,800	46.4
E	R - 2	873,660	15,490		-		56,400		-		-	
	L - 1	1,761,384	9,452		31,800		-		161,350		-	
	Total	2,635,044	10,559	210	31,800	12.7	56,400	22.6	161,350	64.7	-	
F	R - 3	882,309	15,641		-		-		56,400		-	
	L - 2	1,908,000	9,878		-		-		193,150		-	
	Total	2,790,309	11,181	223	-		-		249,550	100	-	

Fig. 5-13 BASIC CONSTRUCTION COST & WATER SOURCES RATIO



CHAPTER 6 TRANSMISSION PLAN FROM CENTRAL SYSTEM TO SEPARATE SYSTEM

CHAPTER 6

TRANSMISSION PLAN FROM CENTRAL SYSTEM TO SEPARATE SYSTEM

6-1 Outline of Central System

The water supply of Bangkok dates from about three hundred years back. The aqueduct which was built in Lopburi about three hundred years ago in order to supply water to the Royal Palace was the first form of water supply, and in the later days of King Rama V the water supply system presently being used was proposed and came into service in 1914.

The population of metropilitan Bangkok has incessantly been increasing from year to year, and in 1976 its population reached 4,559,000 persons. Of them 2,469,000 are now served with water and average daily water demand is 1,177,000 CMD. Of the demand 850,000 CMD is met by the Sam Sen and Thonburi water treatment plants, and the remainder of the demand, or 327,000 CMD, is met by use of ground water.

The water supply system of Bangkok was expanded as its population grew, but demand has always exceeded supply for the past several years. The unrestrained use of groundwater has already involved various problems, such as ground subsidence, the fall of the water table and an increase of salinity in groundwater. Thus, the development of new water sources and the implementation of a comprehensive water supply project have been desired and urgently needed.

To find solutions to these problems, U.S. consultant Camp, Dresser & Mckee (CDM) was called on to draw up a master plan of a water supply project in 1968 and the CDM finished that task in 1970.

In accordance with the master plan, which was made as a long-range projection through year 2000, the water supply project was put into action and the Phase 1 Project (capacity of treated water = 800,000 CMD) of the first stage is now under construction, and the detail design for Phase 2 Project has already been completed. However, the project was badly hindered by the oil crisis and worldwide inflation so that it is far behind schedule. The completion of the Phase 1 Project is now set for 1979. In August 1977 the MWWA reviewed Phase 2 Project in relation to the whole project and made a report "A Review of the Bangkok Water Supply Phase 2 Project".

The present condition and planned scale of the central system are shown in Table 6-1.

Table 6-1 CENTRAL SYSTEM FUTURE WATER REQUIREMENTS

(Prepared by M.W.W.A. Phase 2 Estimate)

Item \ Year (AD)	1976	1979	1981	1985	1990	1995	2000	Remarks
Served Area (Sq. km)	242	—	273	430	—	—	825	
Population to be Served (1,000 Person)	2,469	2,820	3,175	4,059	5,027	6,260	7,797	
Daily Water Consumption per Head (ℓ/c.d.)	477	465	456	465	475	479	482	
Daily Mean Water Demand (1,000 CMD)	1,177	1,311	1,448	1,887	2,338	2,999	3,758	
Daily Maximum Water Demand (1,000 CMD)	1,472	1,639	1,810	2,359	2,985	3,749	4,698	

6-2 Present Condition and Future Plan of Central System

6-2-1 Present Condition :

(1) Surface Water Intake and Aqueduct:

At present surface water is taken from the Chao Phraya river at Sam Lae pump station, located 91 km upstream of the mouth of the river and stored in the Bang Luang Reservoir, located inside the curved section of the Chao Phraya river. From that point water is led south to Sam Sen treatment plant over a distance of 25 km using the Klong Prapa as an aqueduct. On the way to the treatment plant, water is diverted to Thonburi treatment plant at Ban Su which is located about 3 km north of Sam Sen treatment plant.

(2) Water Treatment and Distribution Facilities:

At present two water treatment plants are in operation; Sam Sen and Thon Buri. Sam Sen treatment plant, which consists of 10 systems for purification and treatment, has a capacity of about 680,000 CMD; while Thonburi treatment plant is capable of treating about 170,000 CMD of raw water. The water treated at these plants is then distributed directly to the community.

(3) Groundwater :

As of 1976 about 140 deep wells with a combined daily yield of about 327,000 m^3 were operating in the area over which MWWA has jurisdiction.

6-2-2 Future Plan :

(1) Surface Water Intake and Aqueduct:

No change in the location of the water intake and the route of the aqueduct is envisaged; but, as the amount of water drawn from the river is expected to increase to 6,000,000 CMD (= 70 m^3/sec) in 2000, there is a plan to build a new pump station at Sam Lae, and a plan to improve both the Bang Luang reservoir and the Klong Prapa for use as an aqueduct.

(2) Water Treatment Plants:

In addition to the existing treatment plants at Sam Sen and Thon Buri, a new large-scale plant is under construction at Bang Khen.

Sam Sen treatment plant will be scaled down from the present capacity of 680,000 CMD to 480,000 CMD and Thonburi treatment plant from 170,000 CMD to about 142,000 CMD. Conversely, Bang Khen treatment plant will be expanded to have a final capacity of 4,800,000 CMD; this plant to comprise four systems each of which can treat 1,200,000 CMD of raw water.

(3) Transmission and Distribution Facilities:

Water treated at Sam Sen and Thon Buri treatment plants will be distributed directly to the community. These plants, however, will cover only a small part of the served area, and the greater part of the area will be served by the Bang Khen treatment plant.

Water will be transmitted from Bang Khen treatment plant by underground conduits, 4.6 to 2.0 m in diameter, to 13 service reservoirs from which water will be distributed throughout the entire served area.

(4) Groundwater :

Until completion of the transmission lines from Bang Khen treatment plant, usage of groundwater will increase from 327,000 CMD in 1976 to 532,000 CMD in 1979.

Thereafter the consumption of groundwater will be decreased by about 10 % from year to year until all water demand is met with surface water in 1990.

The outline of the future plan of the central system is shown in Table 6-2.

Table 6-2 CONSTRUCTION OF RAW WATER REQUIREMENTS FOR BANGKOK WATER SUPPLY

Item / Stage	Year (AD)	Raw Water Requirement		Capacity (1,000 CMD)			Daily Demand (1,000 CMD)	
		CMS	1,000 CMD	Plant	Ground Water	Total	Average	Maximum
Present	1977	11	950	850	312	1,162	1,211	1,514
1st Stage - Phase 1	1979	21	1,800	1,622	532	2,154	1,311	1,639
1st Stage - Phase 2	1981	26	2,300	2,022	448	2,470	1,448	1,810
2nd Stage	1985	42	3,600	3,222	294	3,516	1,887	2,359
3rd Stage	1990	54	4,700	4,222	0	4,222	2,388	2,985
Final Stage	1995	70	6,000	5,422	0	5,422	2,999	3,749
	2000	70	6,000	5,422	0	5,422	3,758	4,698

6-3 Brief Review for Transmission Plan from Central System to Separate System

6-3-1 Subject for Review :

In this section the transmission plan from the central system to the separate system will be reviewed so as to make clear whether the water treatment and transmission facilities of the central system can meet not only its demand based on the MWWA report entitled "A Review of the Bangkok Water Supply Phase 2 Project", but the demand of the separate system as well.

(1) Water Demand:

The water demands on the central and separate systems for each phase or stage of construction were estimated by way of two kinds of estimates of water demand for the separate system: Estimate (A) representing the total demand on the separate system; and, Estimate (B) representing the total demand on the separate system minus the demand in the districts served with groundwater. The total water demands on both the central and separate systems for both cases are shown in Table 6-3.

(2) Construction Schedule of Central System:

The planned capacities of the existing treatment plants and Bang Khen treatment plant now under construction are shown in Table 6-4. In this table the water treatment capacity of the central system is divided into surface water and groundwater.

(3) Demand-Supply Balance of Water:

The total water demand on the separate system in 2000, including that in the adjacent development area, is estimated to be 249,550 CMD. This volume accounts for only 5.3 % of the demand of 4,698,000 CMD which the central system will be required to supply in 2000. Thus, the planned capacity of the water treatment and transmission facilities of the central system is large enough to meet the water demands of both the separate and central systems. (See Fig. 6-1).

Table 6-3 DAILY MAXIMUM WATER DEMAND

(CMD)

Item / Stage	Year (AD)	Central System	Separate System		Total	
			(A)	(B)	Case (A)	Case (B)
Present	1977	1,514,000	-	-	1,514,000	1,514,000
1st Stage - Phase 1	1979	1,639,000	-	-	1,639,000	1,639,000
1st Stage - Phase 2	1981	1,810,000	77,980	58,020	1,887,980	1,868,020
2nd Stage	1985	2,359,000	120,040	96,240	2,479,040	2,455,240
3rd Stage	1990	2,985,000	182,450	152,850	3,167,450	3,137,850
Final Stage	1995	3,749,000	219,750	183,850	3,968,750	3,932,850
	2000	4,698,000	249,550	206,650	4,947,550	4,904,650

(A) : All Separate System Area

(B) : Amphoe Nong Khaem
and All Development Areas without Bang Chan

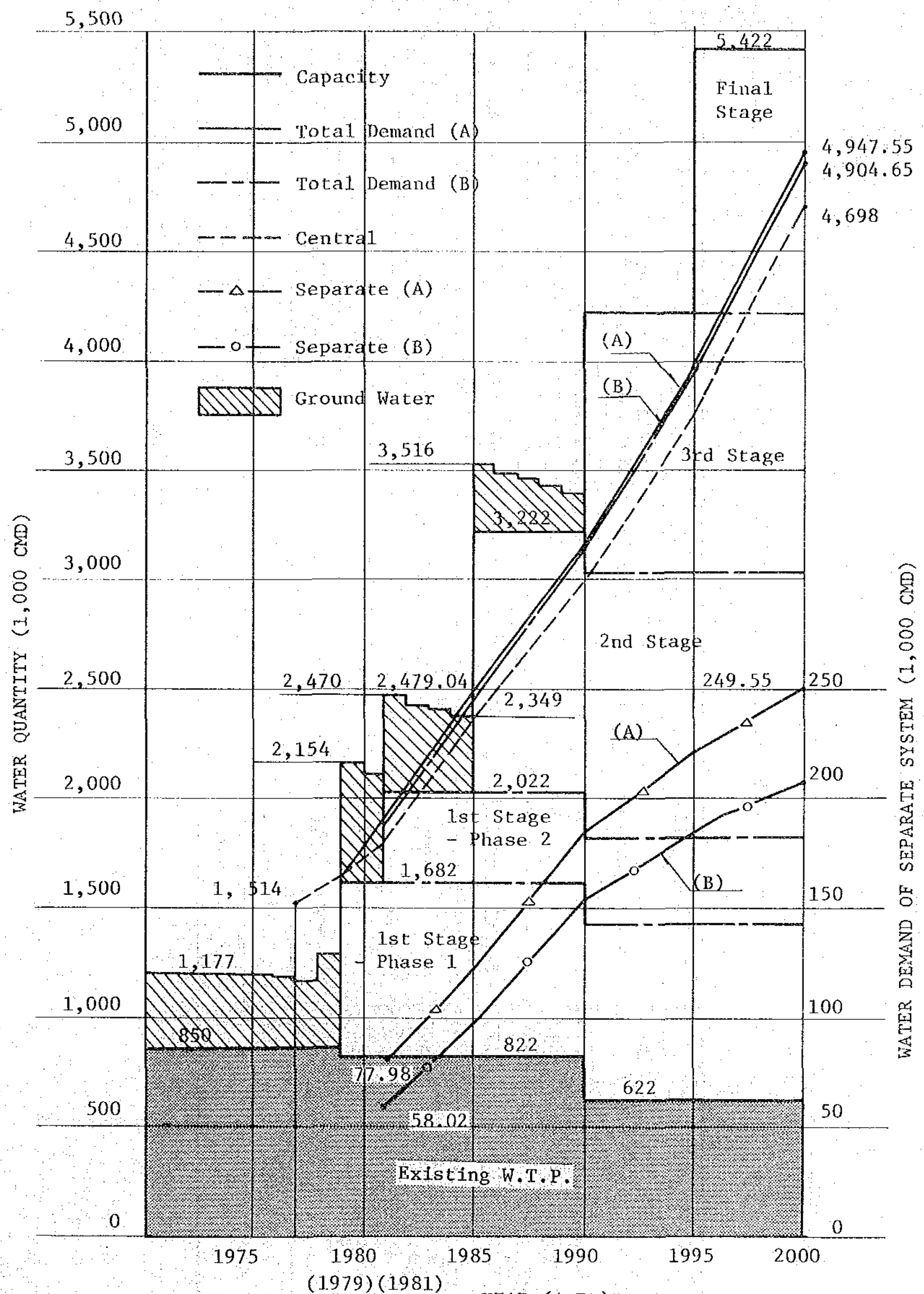
Table 6-4 CONSTRUCTION SCHEDULE OF CENTRAL SYSTEM

(CMD)

Item / Stage	Year (AD)	* Existing Plant		Bang Khen W.T.P.		Surface Water Sub Total	Ground Water		Total
		Abandon	Capacity	Extension	Capacity		Development or Abandon	Capacity	
Present	1977	-	850,000	-	-	850,000	-	312,000	1,162,000
1st Stage Phase 1	1979	-28,000	822,000	800,000	800,000	1,622,000	220,000	532,000	2,154,000
1st Stage Phase 2	1981	-	822,000	400,000	1,200,000	2,022,000	-84,000	448,000	2,470,000
2nd Stage	1985	-	822,000	1,200,000	2,400,000	3,222,000	-154,000	294,000	3,516,000
3rd Stage	1990	-200,000	622,000	1,200,000	3,600,000	4,222,000	-294,000	0	4,222,000
Final Stage	1995	-	622,000	1,200,000	4,800,000	5,422,000	-	0	5,422,000
	2000	-	622,000	-	4,800,000	5,422,000	-	0	5,422,000

* Existing Plant : Sam Sen & Thonburi W.T.P.

Fig.6-1 CONSTRUCTION SCHEDULE OF CENTRAL & SEPARATE SYSTEM



6-3-2 Construction Schedules for Central and Separate Systems:

The separate system is planned to put in service in the entire service area in 1982. In this section the plan will be reviewed in connection with the construction schedule of the central system so as to determine when the separate system related to the central system can put in service.

The service reservoirs of the central system on which the separate system will depend for water, will be located at Tha Phra (Right Bank), Pak Bo and Sam Rong (Left Bank). Tha Phra service reservoir is under construction and is expected to be commissioned upon completion of Phase 1 Project of the first stage (1979), whereas no definite plans for the other two service reservoirs have as yet been formulated. As the construction schedule of the central system through Phase 2 Project (1981) of the first stage has already been decided, Pak Bo and Sam Rong service reservoirs will be planned in the second stage at the earliest or thereafter, depending on the case; but, if the second stage comes as envisaged by the master plan, the two service reservoirs will be completed in 1985.

Therefore, respective to the right bank, it appears that construction of the separate system can satisfactorialy correlate with the central system work; whereas, respective to the left bank, it is required that the second stage work of the central system, especially the construction of the transmission line from Klong Toey to Pak Bo to Sam Rong and service reservoirs, is completed as early as possible.

On the left bank all water from the central system upon which the separate system will depend, will be distributed to the adjacent development area. Any water supply project which starts before water can be diverted from the central system, will have to use groundwater. However, the use of groundwater should be allowed only for a very brief period, and only on condition that a safe margin of pumpage is observed and strictly adhered to.

6-3-3 Study of Demand-Supply Balance and Capacity of Bang Khen Plant:

(1) Demand-Supply Balance of Water:

As has been previously stated, the demand and supply of the central and separate systems as a whole will be in balance. In this section the demand-supply balance of water at Bang Khen treatment plant which will directly supply the separate system will be discussed.

The planned capacity of the Bang Khen plant has already been indicated. The demand which this plant will meet, will be calculated based upon conditions as follows:

1) The wells will be used to the upper limit of the planned capacity.

2) The existing treatment plants will be operated to the upper limit of the planned capacity.

3) Bang Khen treatment plant will meet the estimated demand on the central system minus the supply from the wells and existing treatment plants.

The annual demand which Bang Khen plant will meet when the above conditions are met, can be estimated on the basis of the master plan as shown in Table 6-5. When the planned demands (A) and (B) of the separate system are added to it, Bang Khen plant will have to fill the requirements shown in Table 6-6 and Fig. 6-2.

Bang Khen treatment plant has an adequate capacity to fill the total demand (B) through the final year of the plan, although a supply shortage may occur in the last years of the first or second stages. Before 1984, however, the transmission lines and service reservoirs of the central system will not be completed to supply the service area of the separate system, other than Nong Khaem and Bang Khun Thian on the right bank; and other districts within the service area of the separate system will not be supplied until 1985 when the second stage has been completed. Therefore, the separate system will be actually supplied with 18,100 CMD of water in 1984, while the total demand will be 1,881,000 CMD. Should demand be more than as anticipated in that year, the supply shortage would be only in the order of 5% or so, and such condition would not last for long period of time. This temporary condition is adjudged not particulaly serious since most any system can, in one way or another, be managed to cope with such a slight shortage.

The water demand (B) on the separate system which will be filled by the central system is shown in Tables 6-7 and 6-8 and Fig. 6-3 according to the district and service reservoir.

The total demand on the service reservoirs of the central system is shown in Table 6-9.

Table 6-5 MAXIMUM DAILY DEMAND OF CENTRAL SYSTEM

(1,000 CMD)

Service Reservoir		1st Stage Phase 1	1st Stage Phase 2		2nd Stage	3rd Stage	Final Stage
No.	Name	1979	1981	1982	1985	1990	2000
1	Bang Khen	-	60	88	134	217	300
2	Sam Sen W.T.P.	822	822	822	822	622	622
3	Thonburi W.T.P.						
4	Tha Phra	146	170	204	221	277	332
5	Phahon Yothin	-	75	109	168	224	279
6	Lunpini Park	139	166	200	221	247	273
7	Klong Toey	-	69	100	154	205	256
8	Pak Bo	-	-	-	168	253	388
9	Phra Ram Hok	-	-	-	87	194	300
10	Kaset Sat	-	-	-	-	113	338
11	Rat Burana	-	-	-	90	199	307
12	Yannava	-	-	-	-	116	349
13	Samrong	-	-	-	-	116	350
14	Huai Khwang	-	-	-	-	101	302
15	Bang Thong Lang	-	-	-	-	101	302
Sub Total		1,107	1,362	1,523	2,065	2,985	4,698
Groud Water		532	448	404	294	0	0
Total		1,639	1,810	1,927	2,359	2,985	4,698
*Covered by Bang Khen W.T.P.		285	540	701	1,243	2,363	4,076

*Excluding Sam Sen, Thonburi W.T.P. & Groud Water

Table 6-6 WATER DEMAND COVERED BY BANG KHEN W.T.P.

(CMD)

Stage \ Item	Year (AD)	W.T.P. Capacity	Central System	* Separate System		Total	
				(A)	(B)	Case (A)	Case (B)
Present	1977	-	-	-	-	-	-
1st Stage - Phase 1	1979	800,000	285,000	-	-	285,000	285,000
1st Stage - Phase 2	1981	1,200,000	540,000	77,980	58,020 *(-)	617,980	598,020 *(-)
	1982	1,200,000	701,000	88,500	67,580 *(15,700)	789,500	768,580 *(716,700)
2nd Stage	1985	2,400,000	1,243,000	120,040	96,240	1,363,040	1,339,240
3rd Stage	1990	3,600,000	2,363,000	182,450	152,850	2,545,450	2,515,850
Final Stage	1995	4,800,000	3,127,000	219,750	183,850	3,346,750	3,310,850
	2000	4,800,000	4,076,000	249,550	206,650	4,325,550	4,282,650

* Amount of water from Central System to Separate System at Phase 2.

* Separate System (A) : Total Water Demand of Separate System
(B) : Water Demand covered by Central System

Fig. 6-2 WATER DEMAND COVERED BY BANG KHEN W.T.P.

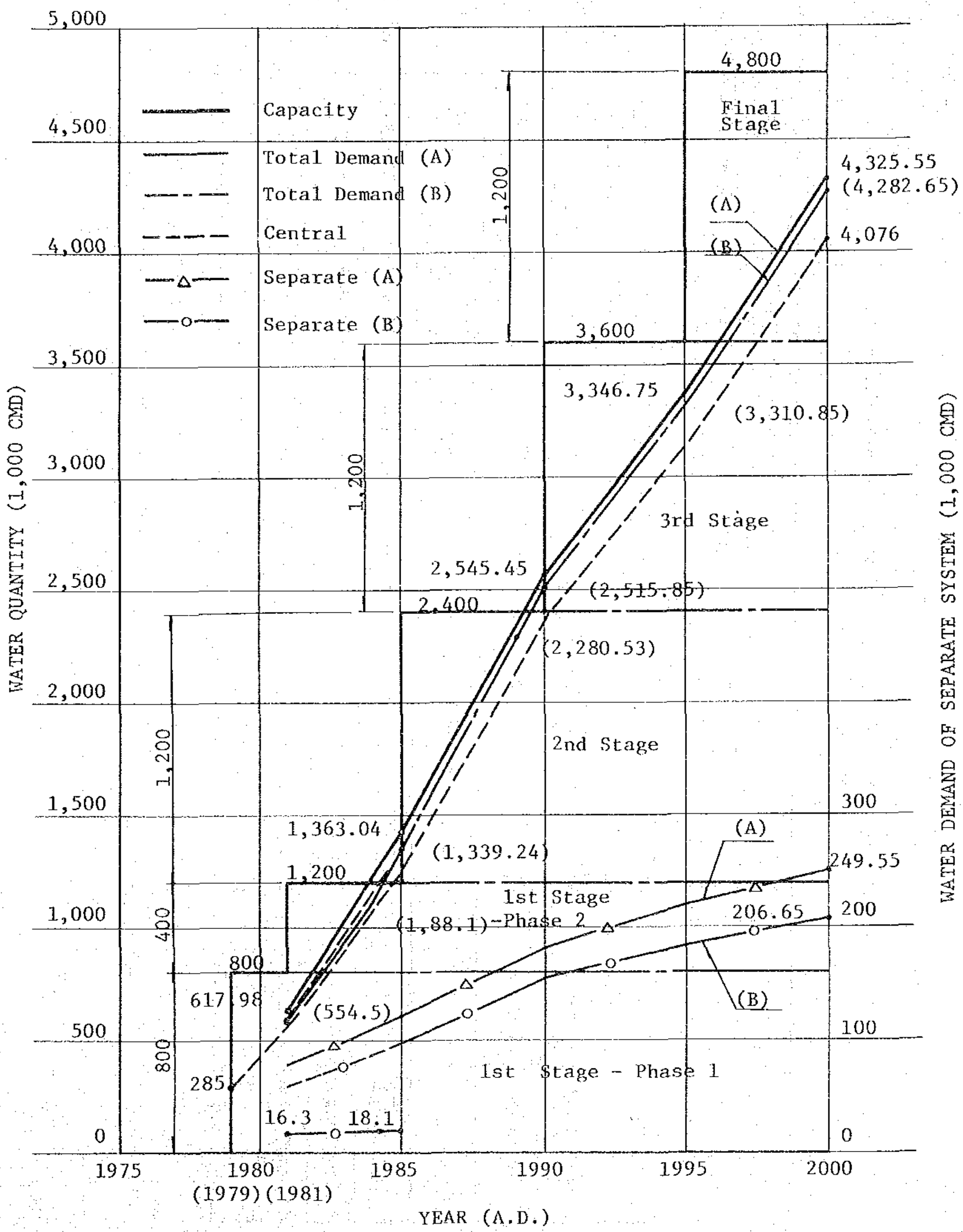


Table 6-7 WATER DEMAND OF SEPARATE SYSTEM (B) COVERED BY CENTRAL SYSTEM

(CMD)

Location				Year (AD) 1980	1981	1982	1985	1990	1995	2000
Right Bank	Nong Khaem District	Nong Khaem	Amphoe	8,000	9,200	10,400	14,000	20,000	28,000	40,000
		Bang Khun Thian	Ho	5,300	5,300	5,300	5,300	5,300	5,300	5,300
		Sub Total		13,300	14,500	15,700	19,300	25,300	33,300	45,300
Left Bank	East Development Program	Lat Krabang	In	5,200	5,200	5,200	5,200	9,850	9,850	9,850
		Lat Krabang	Ho	2,730	4,850	6,970	13,330	26,000	38,000	38,000
		New Airport		1,500	1,600	1,700	2,000	2,500	3,000	3,500
		Sub Total		9,430	11,650	13,870	20,530	38,350	50,850	51,350
	South Development Program	Bang Phli-Bang Bo	In, Ho	5,100	7,240	9,380	15,800	23,800	23,800	23,800
		Bang Poo	In, Ho	15,440	17,980	20,530	28,160	44,700	55,200	65,500
		Klong Dan	In	5,200	6,650	8,100	12,450	20,700	20,700	20,700
		Sub Total		25,740	31,870	38,010	56,410	89,200	99,700	110,000
	Total			35,170	43,520	51,880	76,940	127,550	150,550	161,350
Grand Total				48,470	58,020	67,580	96,240	152,850	183,850	206,650

Note: In : Industrial Development Program

Ho : Housing Development Program

Table 6-8 WATER DEMAND OF SEPARATE SYSTEM COVERED BY CENTRAL SYSTEM RESERVOIR

(CMD)

Reservoir / Year(AD)	Tha Phra (4)	Pak Bo (8)	Samrong (13)	Total
1980	13,300	9,430	25,740	48,470
1981	14,500	11,650	31,870	58,020
1982	15,700	13,870	38,010	67,580
1983	16,900	16,090	44,140	77,130
1984	18,100	18,310	50,280	86,690
1985	19,300	20,530	56,410	96,240
1990	25,300	38,350	89,200	152,850
1995	33,300	50,850	99,700	183,850
2000	45,300	51,350	110,000	206,650

Fig. 6-3 WATER DEMAND OF SEPARATE SYSTEM COVERED BY CENTRAL SYSTEM RESERVOIR

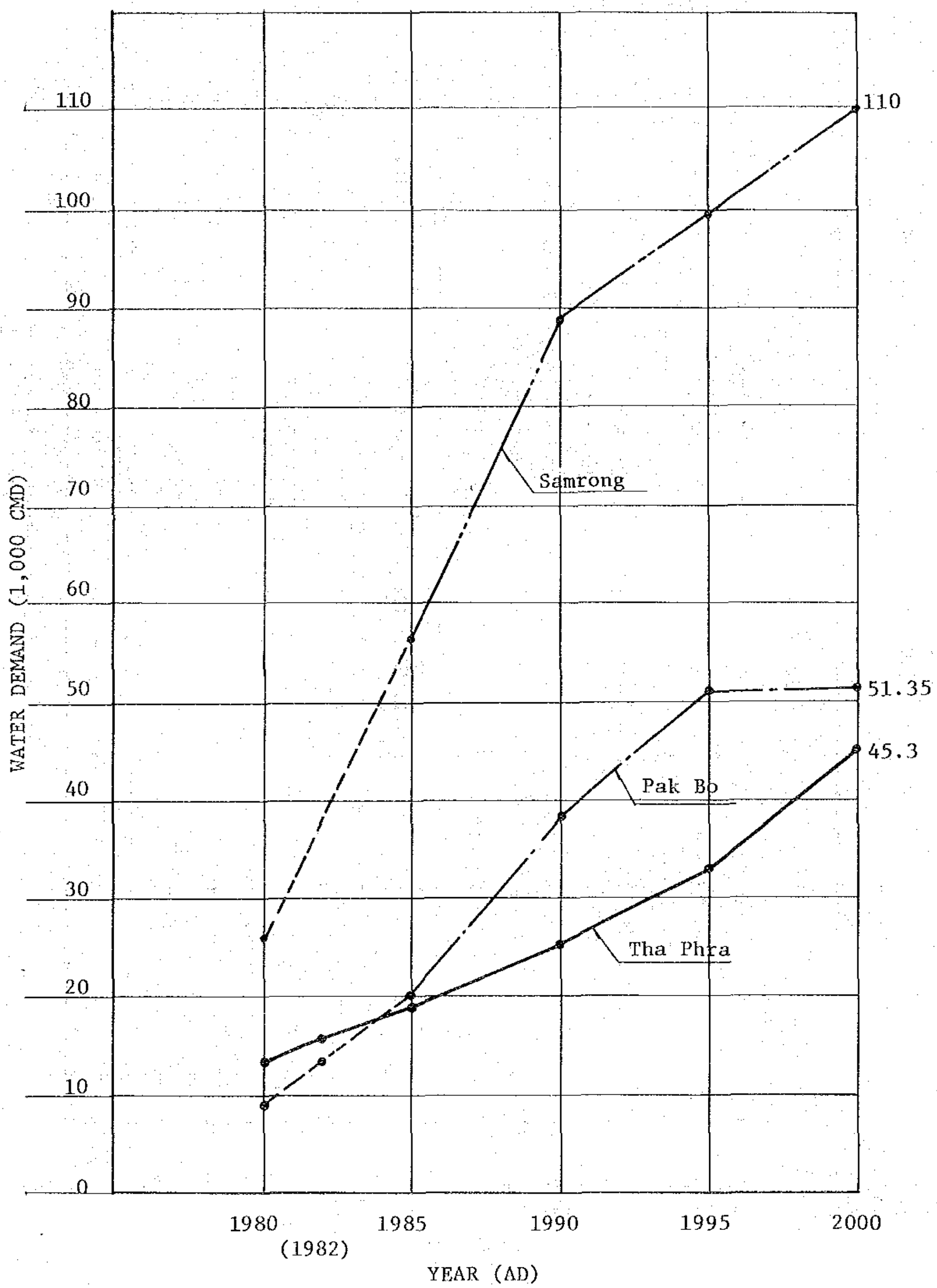


Table 6-9 WATER DEMAND COVERED BY 3 RESERVOIRS

(CMD)

Reservoir	Year (AD)	1980	1981	1982	1985	1990	1995	2000
Tha Phra (No. 4)	Central S.	158,000	170,000	204,000	221,000	277,000	304,500	332,000
	Separate S. (B)	*(13,300)	*(14,500)	15,700	19,300	25,300	33,300	45,300
	Total	158,000	170,000	219,700	240,300	302,300	337,800	377,300
Pak Bo (No. 8)	Central S.	-	-	-	168,000	253,000	320,500	388,000
	Separate S. (B)	*(9,430)	*(11,650)	*(13,870)	20,530	38,350	50,850	51,350
	Total	-	-	-	188,530	291,350	371,350	439,350
Samrong (No. 13)	Central S.	-	-	-	-	116,000	233,000	350,000
	Separate S. (B)	*(25,740)	*(31,870)	*(38,010)	56,410	89,200	99,700	110,000
	Total	-	-	-	56,410	205,200	332,700	460,000

* Water demand which can not be covered by Central System.

(2) Capacity of Bang Khen Water Treatment Plant:

Under this section will be estimated the approximate capacities of the rapid settling basin, rapid filtration basin and clear-water basin of Bang Khen water treatment plant which will be required for not only its own demand but the demand (B) on the separate system in 2000.

1) Rapid Settling Basin:

i) Dimensions : 58.0 (dia.) x 5.3 m (H) x 24 units $= 335{,}760\ m^3$

ii) Capacity : 200,000 CMD/unit

iii) Detention period (central) : $\dfrac{335{,}760\ m^3}{4{,}076{,}000\ m^3/day} \times 24\ hr = 1.98\ hr$

iv) Detention period (total) : $\dfrac{335{,}760\ m^3}{4{,}282{,}650\ m^3/day} \times 24\ hr = 1.88\ hr$

2) Rapid Filtration Basin (Anthracite with Sand):

i) Dimensions : 9.35 m (W) x 27.4 m (L) x 80 units $= 20{,}495\ m^2$

ii) Filtration speed (central) : $\dfrac{4{,}076{,}000\ m^3/day}{20{,}495\ m^2} = 198.8\ m/day$

iii) Filtration speed (total) : $\dfrac{4{,}282{,}650\ m^3/day}{20{,}495\ m^2} = 209.0\ m/day$

3) Clear-water Basin:

i) Dimensions : 70 m (W) x 180 m (L) x 6 m (H) x 8 units $= 604{,}800\ m^3$

ii) Detention time (central) : $\dfrac{604{,}800\ m^3}{4{,}076{,}000\ m^3/day} \times 24\ hr = 3.56\ hr$

iii) Detention time (total) : $\dfrac{604{,}800\ m^3}{4{,}282{,}650\ m^3/day} \times 24\ hr = 3.39\ hr$

As shown above, all the basins have an adequate capacity to permit the water treatment plant to perform as required.

The site plan of Bang Khen water treatment plant is shown in Fig. 6-4.

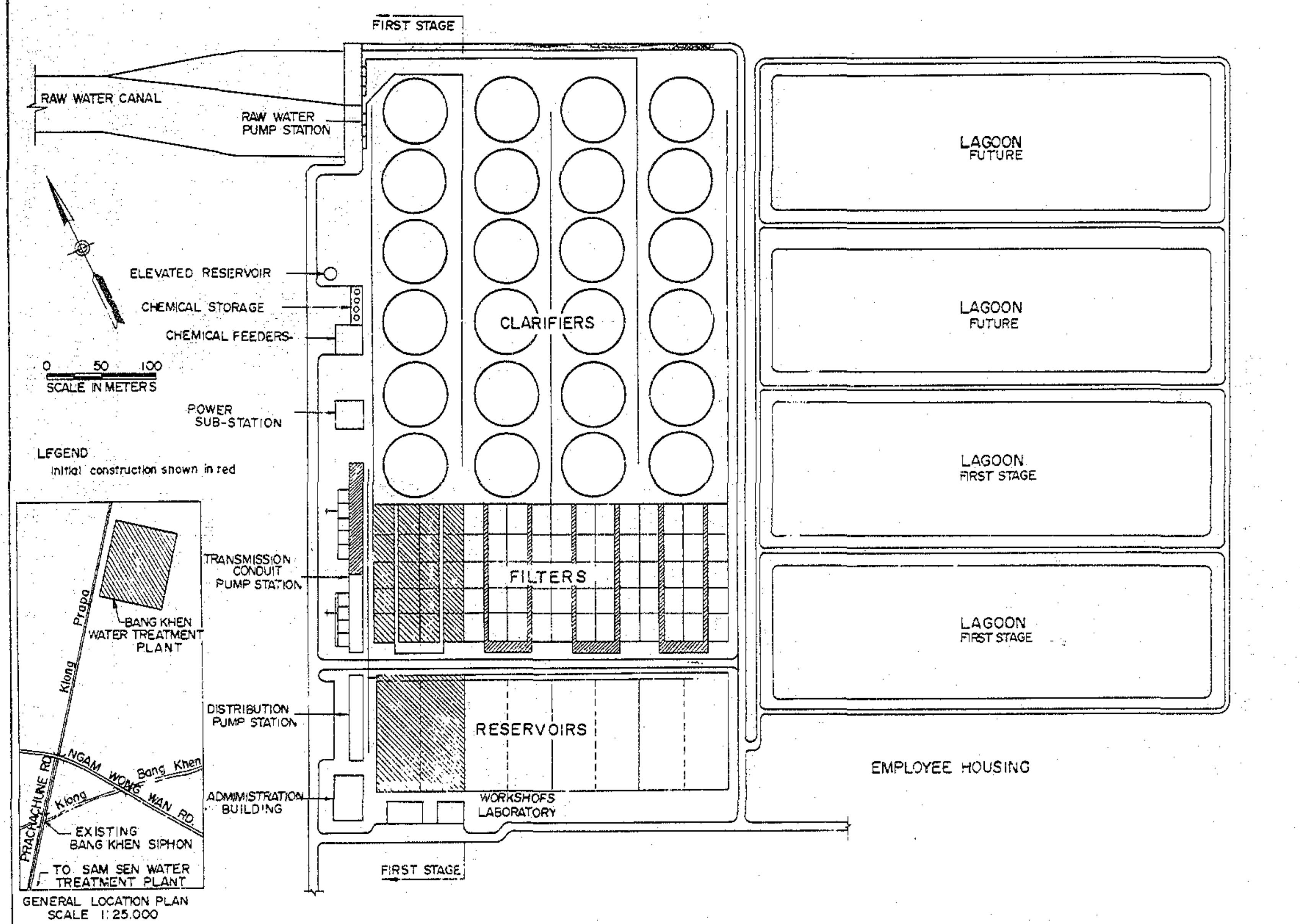


Fig 6-4 BANG KHEN WATER TREATMENT PLANT - SITE PLAN

(3) Capacity of the Transmission System:

This section will deal with a hydraulic study of the transmission system which will transmit water from Bang Khen water treatment plant to 13 service reservoirs in the community in order to fill the demands of both the central and separate systems.

This hydraulic study assumes two cases : (A)and(B). In Case(A)the demands of both the central and separate systems will be filled, while in Case(B)the demand filled by wells in the service area of the separate system will be omitted.

For Case(A)the transmission system only in 2000 will be considered, whereas for Case(B)the hydraulic study will cover the transmission system in each stage of construction.

The hydraulic study is based upon assumptions as follows:

1) The pipe sizes and route lengths shown in the detail design will be adopted in the first stage.

2) In the second and subsequent stages, pipelines will be laid according to the master plan, except that the route leading to Yannava will be branched off at Lumpini Park.

3) In the second and subsequent stages, the pipe sizes shown in the master plan will be employed for the loop, but pipes 2.0 m in diameter will be used in all the branches in accord with the detail design.

4) The amount of water which each service reservoir will receive,will be decided in accord with the master plan. (See Table 6-5.)

The transmission route from Bang Khen treatment plant to each service reservoir is indicated in Fig.6-5, and the results of the hydraulic study of the transmission system are shown in Figs. 6-6 through 6-11.

(4) Capacity of the Service Reservoir:

The capacity of the service reservoir of central system was in principle decided to be 10 % of the daily maximum water demand.

In the master plan, the service reservoirs of central system are arranged so that each service reservoir can receive about 300,000 to 400,000 CMD of water. Accordingly, all but Pak Bo service reservoir with a capacity of 50,000 m^3 are planned to receive 40,000 m^3. But, when the water demand on the separate system is also taken into account, capacity of Sam Rong service reservoir needs to be increased from 40,000 CMD to 50,000 CMD.

However, expansion of Samrong service reservoir seems not necessary since installation of service reservoir for each Amphoe and adjacent development area are planed in their proposed served area.

(5) Method of Transmission to the Separate System:

Transmission of water from the central system to the separate system is planned to be accomplished by a newly built pumping facility. It is desirable that this pumping facility is planned as a part of that of the central system and is located in the premises of the service reservoir. If none of the site of service reservoirs can afford land for the pumping facility, a independent pumping station for separate system will have to be built near one of the service reservoirs of central system.

Prior to the completion of the 2nd stage construction of the central system, and in case the water transmission to the separate system on the left bank area is provided by independent transmission main systems from Klong Toey reservoir to Pak Bo and Samrong reservoirs, to meet water demands for years 1984 and 2000, the construction cost of these transmission main systems are estimated as 145×10^6 ฿ and 244×10^6 ฿, respectively.

Fig 6-5 TRANSMISSION LINE

Fig. 6-6 1st. STAGE - PHASE 2 (1981 AD)

Flow Coefficient : C = 110 Capacity 1,200 (1,000 CMD)

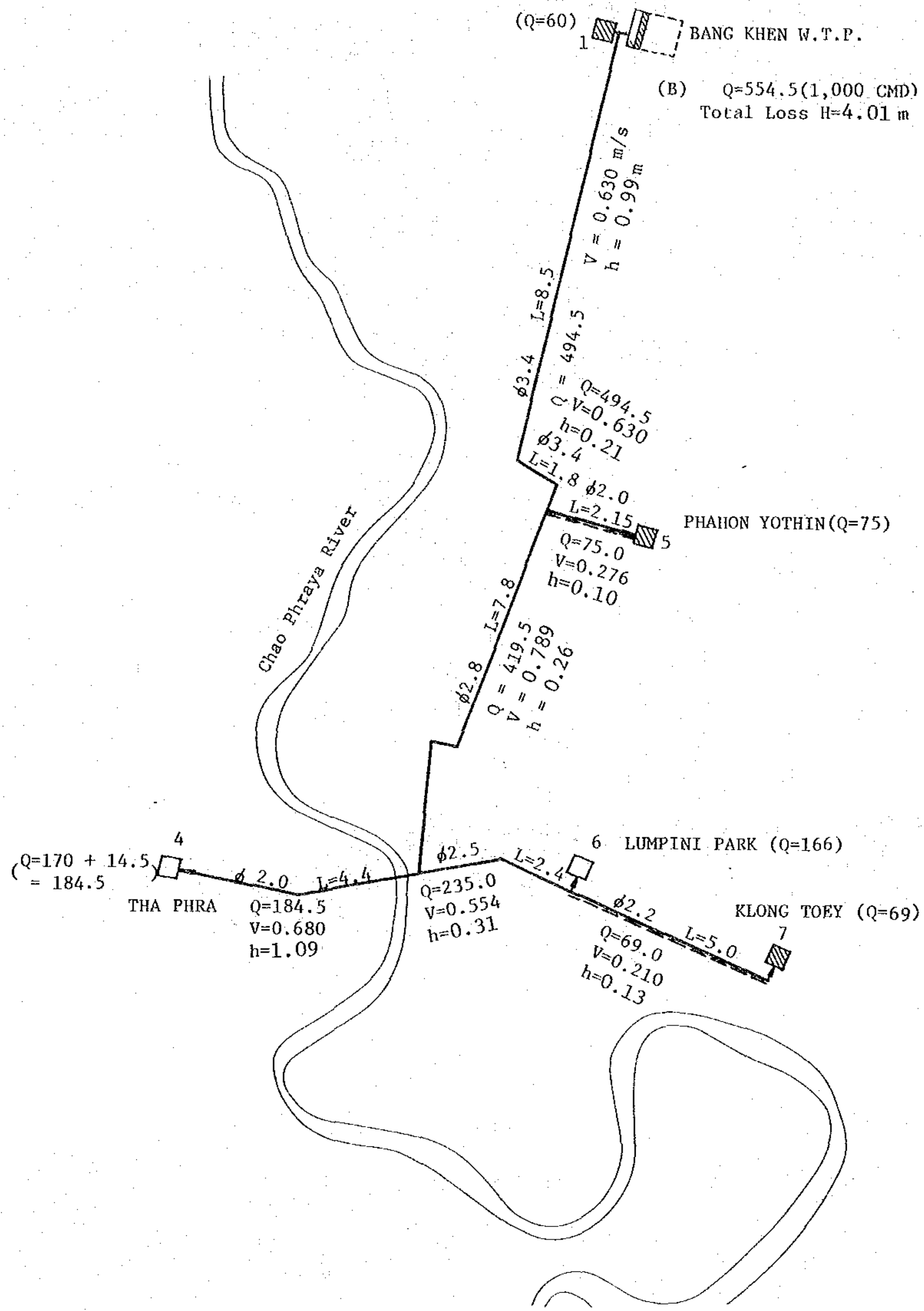


Fig. 6-7 1st. STAGE - PHASE 2 (1982 AD)

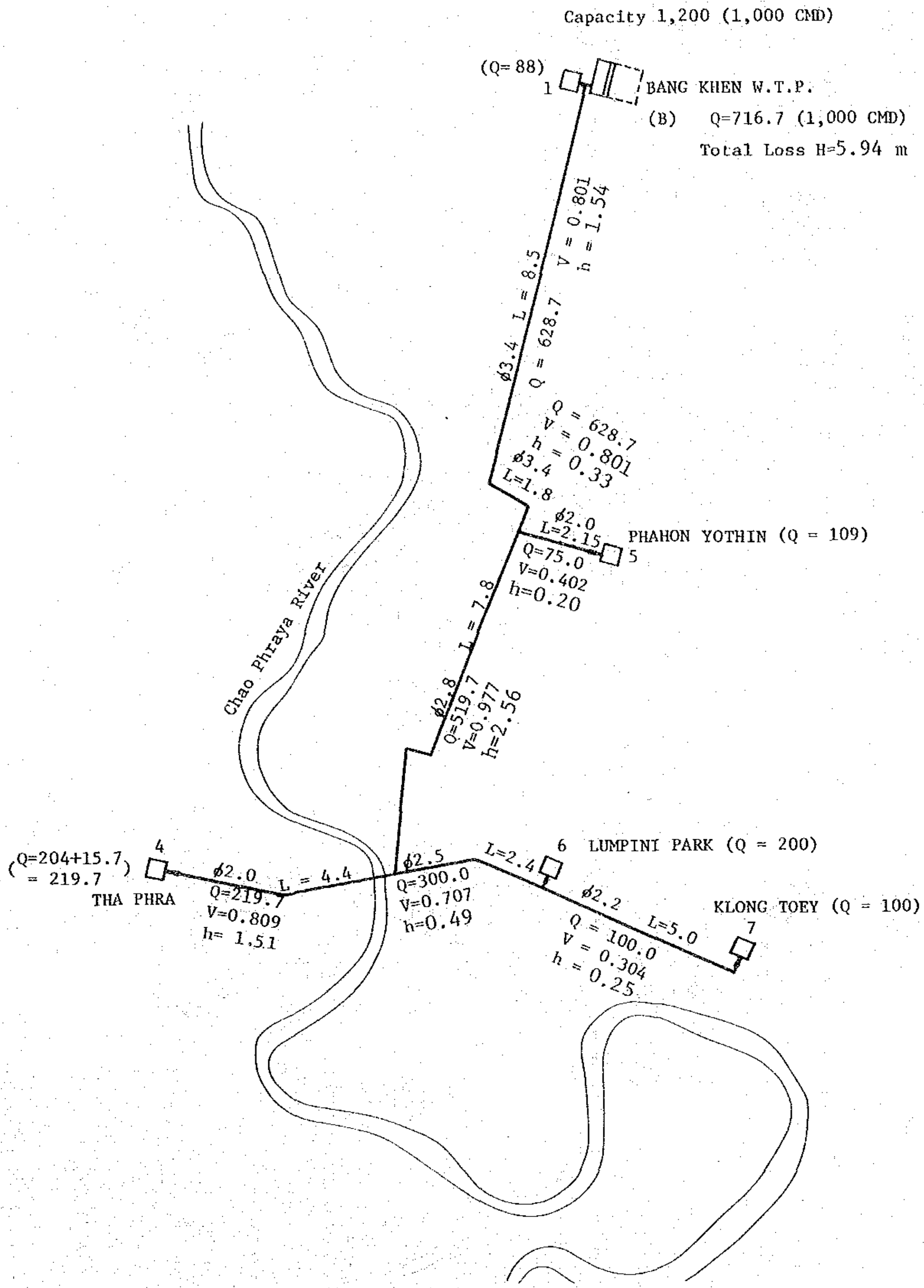


Fig. 6-8 2nd. STAGE (1985 AD)

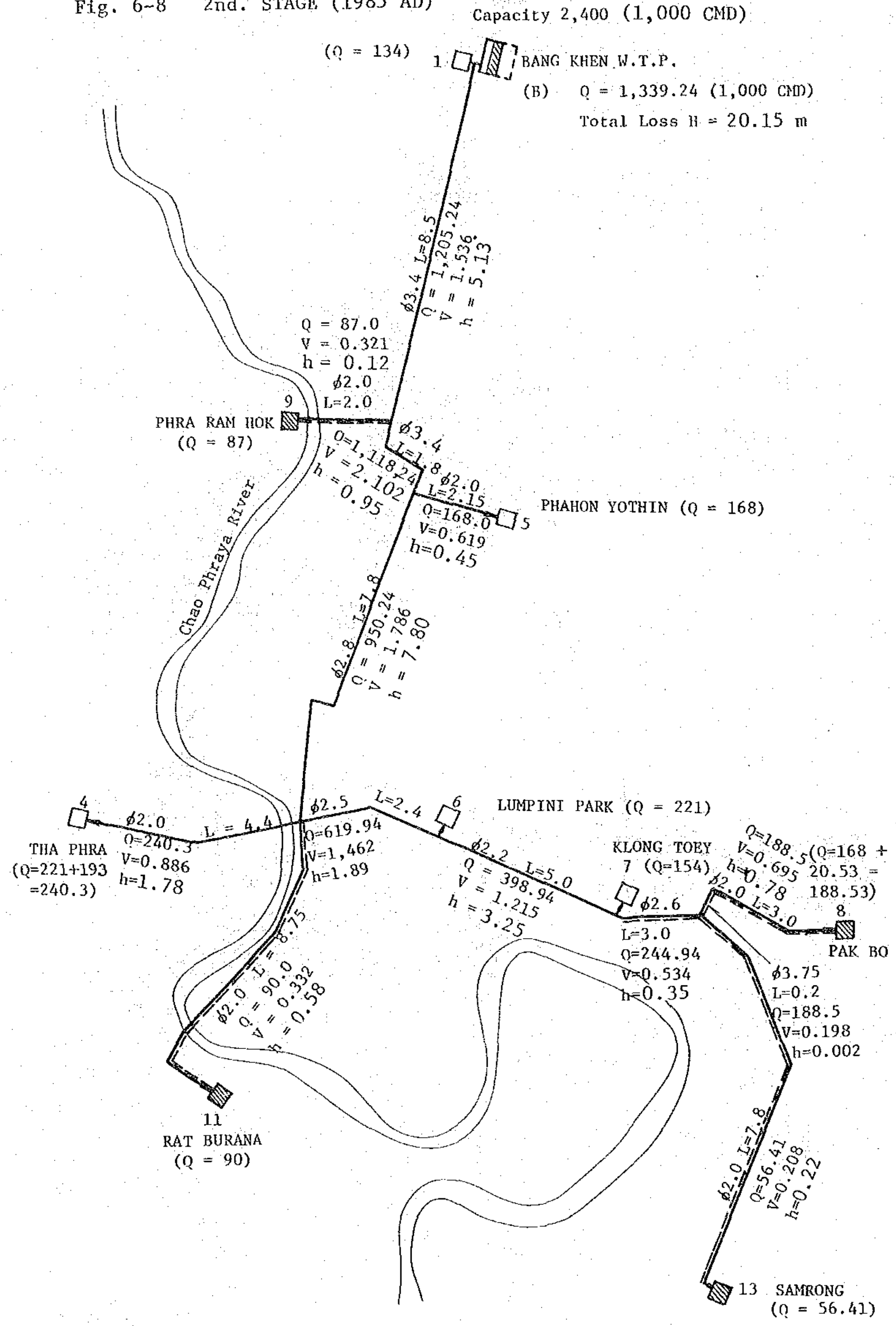


Fig. 6-9 3rd. STAGE (1990 AD)

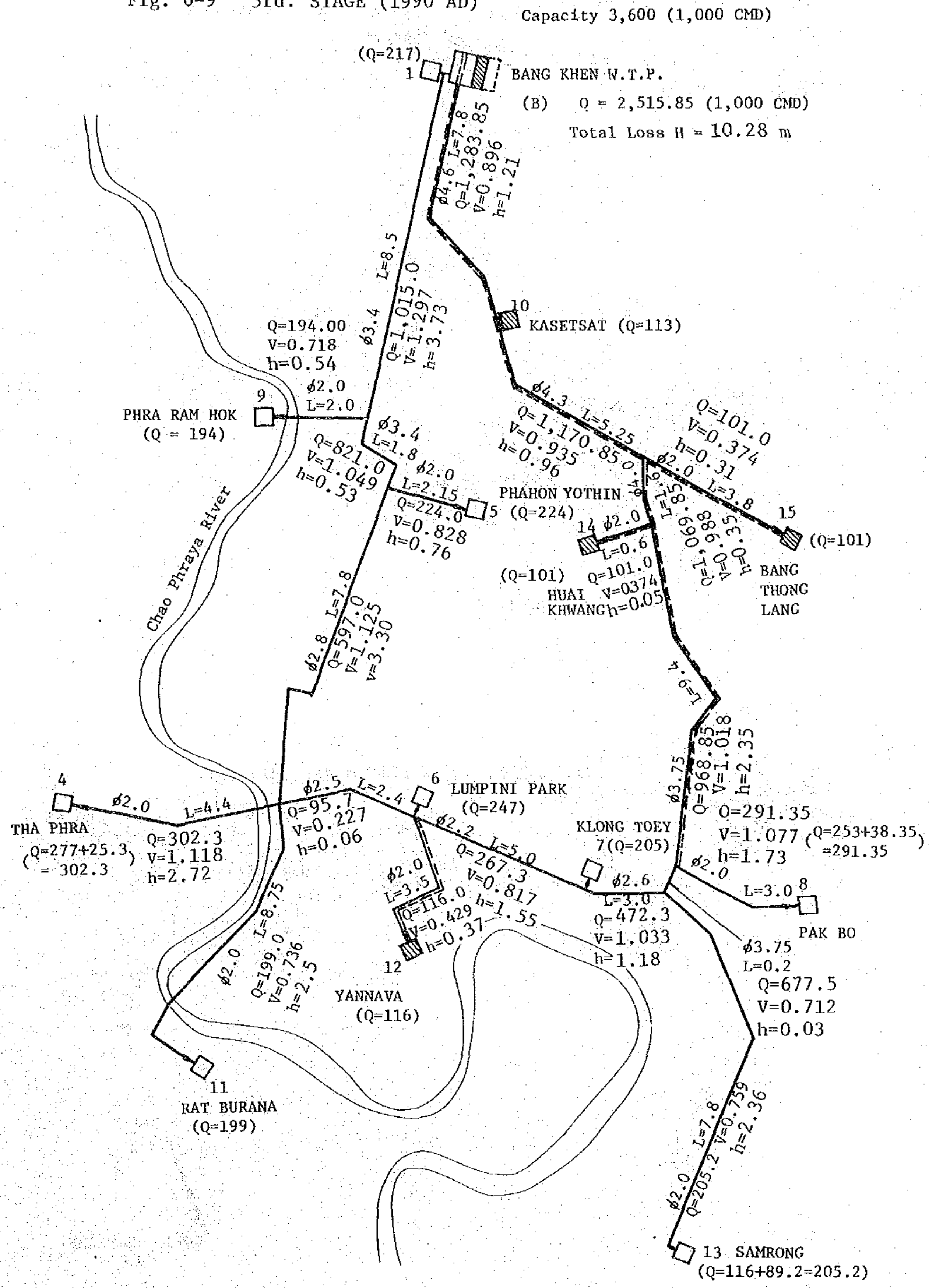


Fig. 6-10 FINAL STAGE (2000 AD)

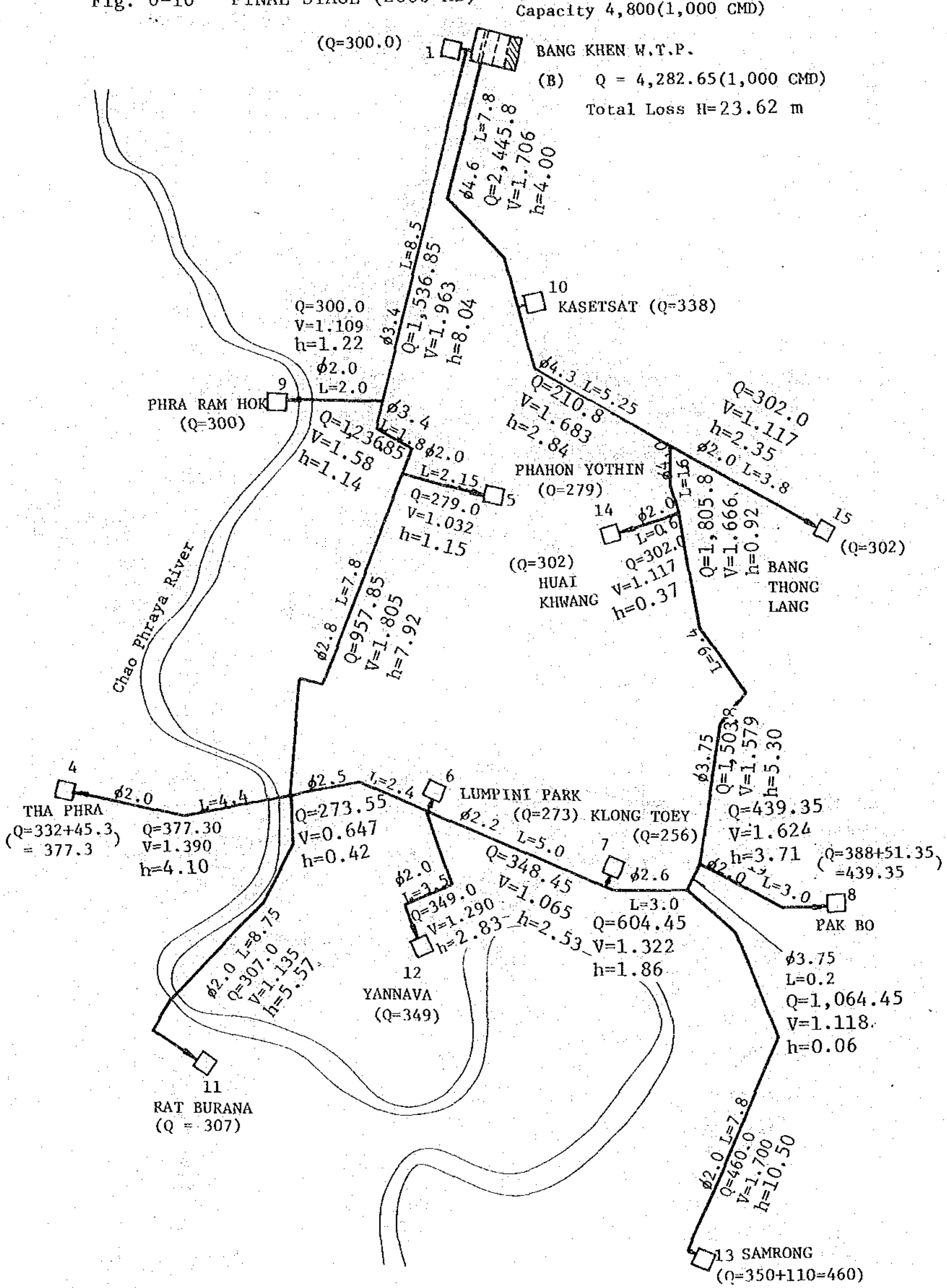
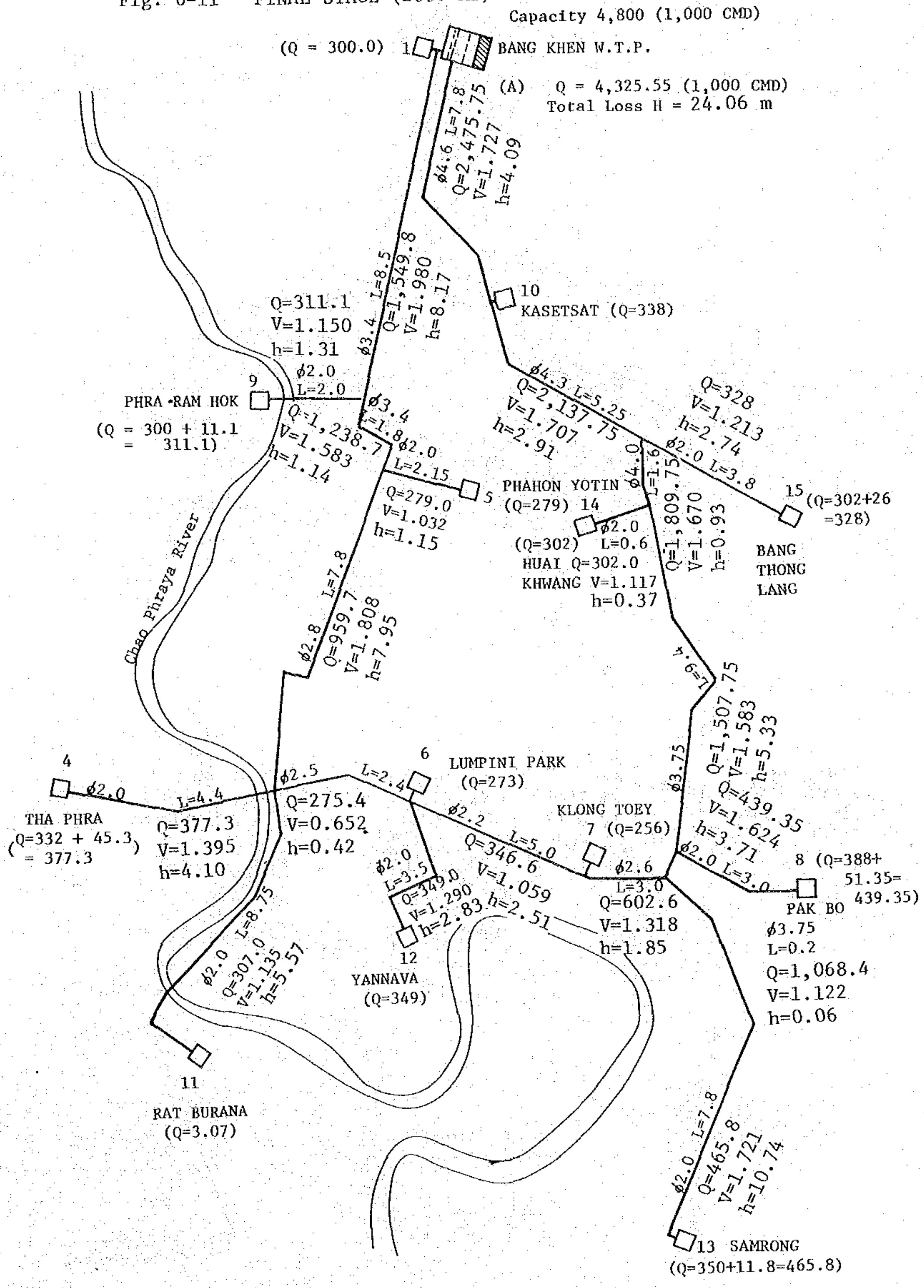


Fig. 6-11 FINAL STAGE (2000 AD)



6-4 Discussion

CDM, who prepared the master plan of the Bangkok water supply project, planned the separate system independently of the central system. However, as time went on, the separate system including the housing and industrial projects acquired increasing importance until its water demand could no longer be met by using groundwater alone. As a result, the diversion of water from the central system was planned; the notable aspect of this plan being the fact that the project was promoted by MWWA and at its own discretion.

To review the plan of the central system and modify part of it to suit the convenience of the separate system, it might threaten to be criticized as loss of identity for the engineering. An effort to find other water sources might be rewardable if MWWA planned a water supply project for one hundred years hence; but, the problem of an alternative water source cannot possibly be solved in the foreseeable future, save the singular possibility that a project of finding a new water source is undertaken on a national level.

As recommended under Chapter 2, the study of the feasibility, scale and time of diverting water from the central system should be commenced immediately. Furthermore, it is most desirable that experts in principle lead the study in accordance with the procedures set forth in Sec. 2-4-3.