2-3 Relationship with Central System

2-3-1 History of the Feasibility study :

As mentioned in Sec. 2-1, the reviewing of the central system by J.I.C.A. as an additional assignment was accepted with the proviso "in case it would be better for the separate system to divert water from the central system".

The idea of diverting water from the central system apparently arose when a feasibility study of the water supply project for 5 Amphoes was conducted in 1972. As a matter of fact, part of the feasibility study report prepared in March 1972 reads as follows:

"When Dr. S. Naito carried out a basic survey for the separate system from September 1971 to March 1972, it was never mentioned in metropolitan Bangkok that the decided service area of the central system should be expanded to include the service area of the separate system or water should be diverted from the central system to fill the demand on the separate system."

Those days the separate system was not related to the central system, reflecting an easy-going view that, as C.D.M. stated in its report, the separate system would be relatively easy to build. There was a view that as much water as wanted could be obtained by digging wells. However, the groundwater survey which was taken in Nong Khaem following the basic survey led by Dr. S. Naito proved a failure and the groundwater in Sai Noi was found to be contaminated by saline water. Confronted with an unexpected situation, the persons charged with the water supply project had to review the separate system from the standpoint of water source.

In other words, it became necessary to find a relatively easy solution to the problem by turning to the central system for a water supply. Needless to say, the central system was planned as an independent system and was already under construction. It was therefore difficult to fill all the demand on the separate system with water diverted from the central system and it was economically disadvantageous to divert water from the central system to the separate system far away. As a result, the possibility of supplying Nong Khaem near Thon Buri with water diverted from the central system was studied.

2-3-2 Limit of Reviewing Work of the Central System :

Nobody would refute that the water supply project in Nong Khaem will be a poor investment, if the water works there will not rely on the central system for a water supply. It must be also a fact that other districts to be covered by the separate system were considered in the same way as Nong Khaem. However, the scope of work agreed on between M.W.W.A. and J.I.C.A. sets a certain limit on the review of the central system and will in principle not permit any significant changes in the detail design of the central system as made by C.D.M., U.S. consultant, and at the expense of a great deal of time and money.

The basic plan of the central system generally consists of taking raw water from more than one water source, producing purified water in Bang Khen treatment plant (final planned capacity : 4,800,000 CMD) and the two existing treatment plants (Sam Sen treatment plant with a present capacity of 680,000 CMD and Thon Buri treatment plant with a present capacity of 170,000 CMD). In 2000 the existing treatment plant, Sam Sen and Thon Buri, will directly supply water to the served area, and Bang Khen treatment plant will supply water to 13 service reservoirs through underground transmission line, with a treatment capacity of 5,422,000 CMD in total.

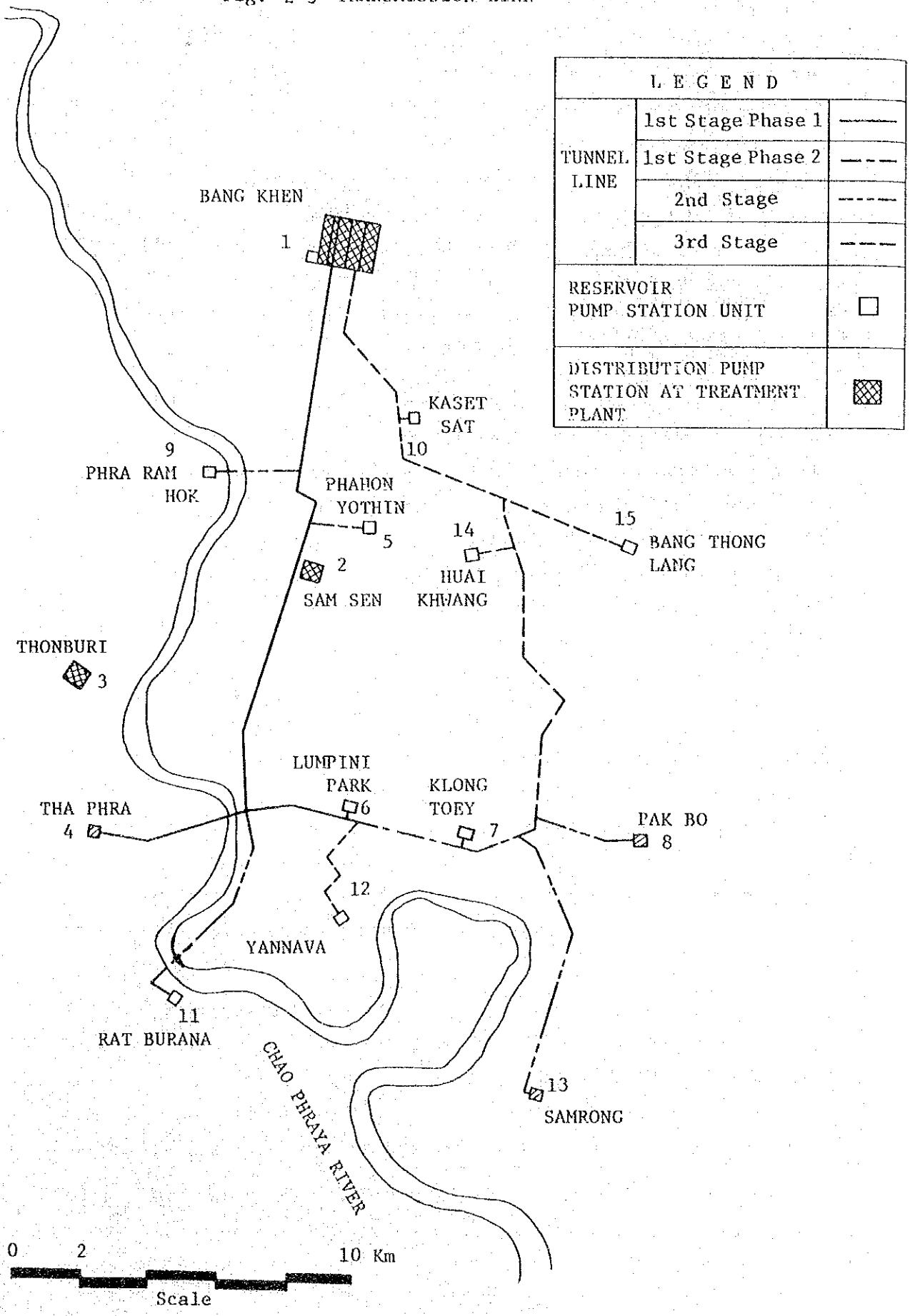
When the diversion of water from the central system is considered, Bang Khen treatment plant acquires importance as a plant which will have a direct relationship with the separate system. Accordingly, the review of the central system will be mainly concerned with Bang Khen treatment plant. However, the scope of work does not in principle permit reviewing the facilities forward of the treatment plant.

Since the review of the central system is limited to only Bang Khen treatment plant and the facilities, downstream from that plant, the approximate capacity of Bang Khen treatment plant, the transmission lines and the capacity of the service reservoirs will be the matters which may be reviewed in this feasibility study.

The construction schedule of the central system recentrly revised in March 1977 now provides for a staged construction schedule so as to increase its capacity by 800,000 CMD in 1979, 400,000 CMD in

1981, 1,200,000 CMD in 1985, 1,200,000 CMD in 1990 and 1,200,000 CMD in 1995 as shown in Table 2-3. This plan is related to the production capacity of Bang Khen treatment plant and its capacity expansion through the second stage or through 1985 is a question at issue. As has been mentioned, this review of the central system in relation to the separate system should be limited to the portion of the water supply project to be implemented after the second stage; thus, this feasibility study report will deal with the sedimentation basin, filter basin and ancillary facilities for Bang Khen treatment plant and the transmission lines. These lines are indicated by dash lines and the service reservoirs are indicated by shaded boxes in Fig. 2-3.

Fig. 2-3 TRANSMISSION LINE



2-3-3 Considerations for the Central System :

The water demand on the central system will be reviewed by assuming two cases as follows:

(A) The total demand on the separate system is added to that of the central system.

(B) The total demand on the separate system minus an amount for groundwater supply (for 8 Amphoes excluding Nong Khaem and the Bang Chan) is added to that of the central system.

Case (A) assumes that the central and separate systems will be integrated into one system in the future, whereas case (B) is a more practical proposition which assumes that groundwater, if available and fit for use, will be used where possible and in preference to other water sources.

The estimated water demands on the central and separate systems are shown in Table 2-1.

Table 2-1 WATER DEMAND ON CENTRAL AND SEPARATE SYSTEMS

(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
2 nd Stage	1985	2,359,000	120,040	96,240	2,479,040	2,455,240
3 rd 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

Table 2-2 shows the total water demand of the central system and the water supply capacity from San Sen, Thonburi and Bang Khen treatment plants, and from wells serving the central system area.

Table 2-3 shows the water production capacity of Bang Khen treatment

plant and the water demand in the central and separate system areas in which water is supplied from Bang Khen treatment plant.

Table 2-2 WATER DEMAND IN CENTRAL SYSTEM COVERED BY WELL & WATER TREATMENT PLANT

(CMD)

Item / Stage	Year (AD)	Water Demand	Well & Water Treatment Plant		
			Sam Sen & Thonburi W.T.P.	Groundwater	Bang Khen W.T.P.
1st Stage Phase 1	1979	1,639,000	822,000	532,000	285,000
1st Stage Phase 2	1981	1,810,000	822,000	448,000	540,000
	1982	1,927,000	822,000	404,000	701,000
2nd Stage	1985	2,359,000	822,000	294,000	1,243,000
3rd Stage	1990	2,985,000	622,000	0	2,363,000
Final Stage	1995	3,749,000	622,000	0	3,127,000
	2000	4,698,000	622,000	0	4,076,000

Table 2-3 WATER DEMAND IN AREAS SERVED BY BANG KHEN WATER TREATMENT PLANT

(CMD)

Item / Stage	Year (AD)	W.T.P. Capacity	Central System	Separate System	Total
Present	1977	-	-	-	-
1st Stage Phase 1	1979	800,000	285,000	-	285,000
1st Stage Phase 2	1981	1,200,000	540,000	-	540,000
2nd Stage	1985	2,400,000	1,243,000	96,240	1,339,240
3rd Stage	1990	3,600,000	2,363,000	152,850	2,515,850
Final Stage	1995	4,800,000	3,127,000	183,850	3,310,850
	2000	4,800,000	4,076,000	206,650	4,282,650

As far as judged from Table 2-3, Bang Khen treatment plant (final planned capacity: 4,800,000 CMD) can fill not only the demand on the central system but the demand on the separate system, and its main facilities (clarifier, rapid sand filter and clear-water reservoir) need no modification to fill the demand on the separate system as well.

As the velocity of water flow in the pipes in 2000 is estimated to be 2.0 m/sec, the planned transmission line will not pose any problem from a hydraulic point of view. However, the transmission pump will need some specification changes in order to cope with an increase in the water flow rate and a resulting increase in the head loss.

If the separate system turns to the central system for its water supply, water might be diverted from the central system in the first stage of construction to supply the right bank area of the Chao Phraya river and in the second stage to supply the left bank area. On the right bank, the construction periods of the central and separate systems can be easily matched, since water will be diverted from the central system in its first stage of construction, whereas the detail design of the central system of second stage for the left bank has not yet been undertaken. It appears desirable that the detail design for the left bank systems be developed as early as possible so as to match the construction periods of both the central and separate systems.

If it is feasible to divert water from the central system to fill the demand on the separate system, the plan to rely on it will be far more advantageous, both economically and technically, than the plan to tap an independent source of surface water for the separate system. To confirm the feasibility of the former plan, it is necessary to closely scrutize the plan of the entire central system. However, as mentioned earlier, a detailed review of the central system cannot be undertaken unless and until M.W.W.A. decides officially to depend on the central system to fill the demand on the separate system and formally undertakes a more current review of the whole central system.

2-3-4 Water Source of the Central System :

Since the separate system accounts for only 5 % or so of the central system, it may not be realistic to discuss the water source of the central system even if the separate system is to rely on the central system for water.

However, there is only 25 m^3/sec or 2,160,000 CMD of water exists in the flow of Chao Phraya river for the purpose of water supply (See Note 1). As is clear from Table 2-1, this water source cannot fill the demand later than 1981; that is, the first stage.

On the other hand, the Nakhon Chai Si river, which could supply the service area of the separate system on the right bank of the Chao Phraya river, if developed, is a tributary of the Chao Phraya river. And, it is reported that RID has a plan to limit the amount of water withdrawn from the Chao Phraya river to 50 m^3/sec, and this to be allocated as 30 m^3/sec to prevent the intrusion of sea water into the resource and the remainding 20 m^3/sec to supply the community.

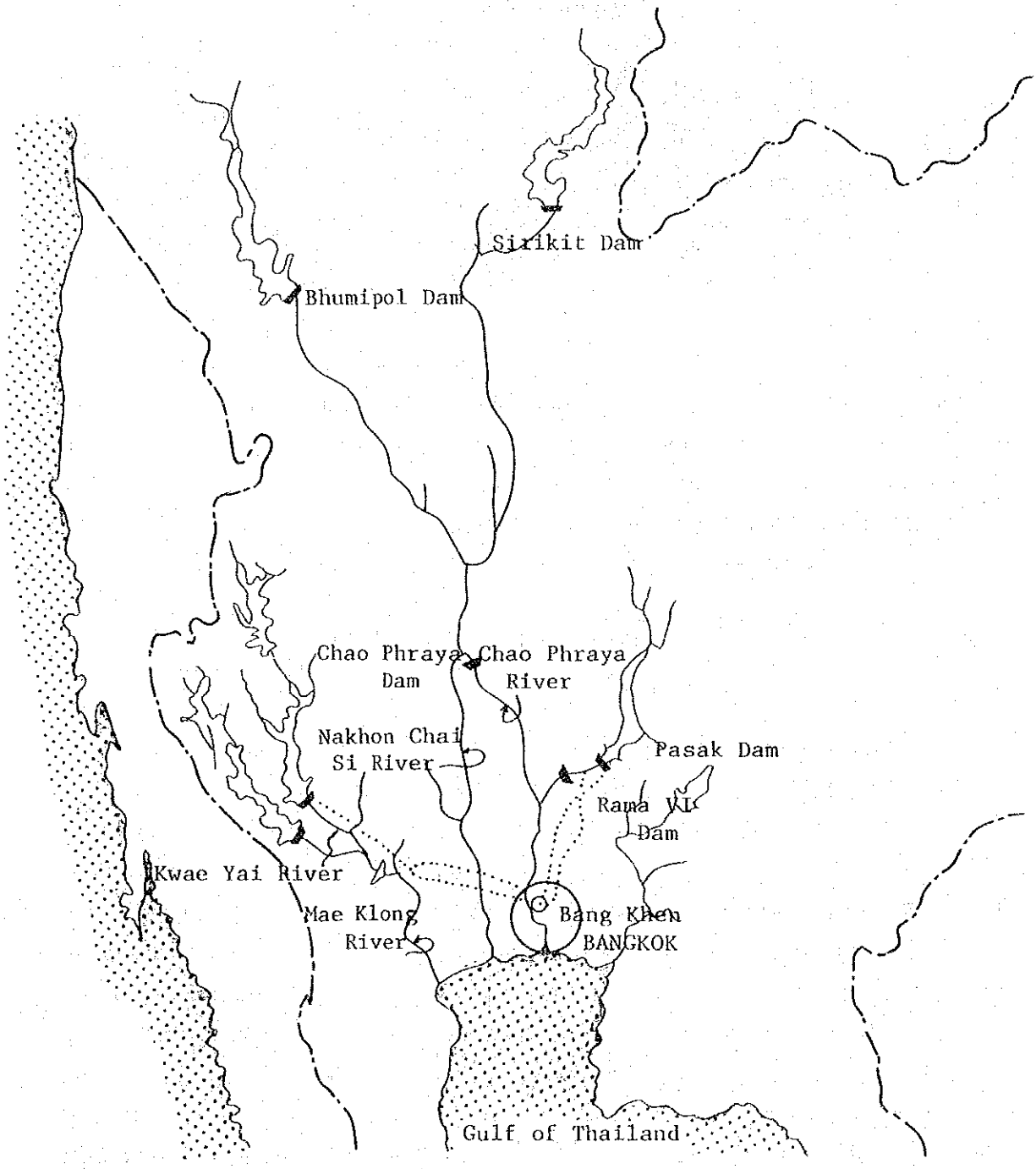
The demand for surface water in 2000 is expected to be such that it cannot be filled unless water is taken at a rate of 70 m^3/sec. Even if water can be taken from the Chao Phraya river at a rate of 25 m^3/sec and from the Nakhon Chai Si river at a rate of 20 m^3/sec, there will still be a supply shortage of 25 m^3/sec. There are plans to develop such water sources as the Kwae Yai river about 150 km west of Bangkok and the Pasak river which is a medium tributary of the Chao Phraya river in order to make good the supply shortage. The plan to develop the Kwae Yai river seems impractical as water must be carried over a long distance by an aqueduct or through use of the existing agricultural channel. The plan to tap the Pasak river, on the other hand, also needs a long distance, if water is to be carried directly from the dam, but this plan will be relatively easier to implement if the existing channel is utilized. (See Fig. 2.4).

However, these development plans are under the jurisdiction of other enterprises such as Electricity Generating Authority of Thailand, and the government such the Royal Irrigation Department; and reckoning with these as new water sources presupposes prior agreement with such

an enterprise or government agency.

* NOTE 1 : Contrary to the hope that the water flow rate of the Chao Phraya river near its mouth would increase to 120 m^3/sec when the Sirikit Dam was completed, a recent survey taken by R.I.D. indicates that its water flow rate near the mouth will be only 85 m^3/sec. When the flow rate of 60 m^3/sec required to prevent the intrusion of saline water into the river is considered, the central system cannot take more water from this river than at a rate of 25 m^3/sec.

Fig. 2-4 PROPOSED DEVELOPING PLAN FOR WATER SOURCE OF CENTRAL SYSTEM



2-4 Proposed Plan of Separate System

2-4-1 Specifications :

(1) Planned Service Areas :

1) Amphoes :

Right Bank : 4 Amphoes
Left Bank : 5 Amphoes } 9 Amphoes

2) Adjacent Development Areas :

Right Bank : 1 Development Program
Left Bank : 7 Development Programs

(2) Target Year : 2000 AD (Start to Supplying at 1982)

(3) Size of Areas :

Administrative Area (9 Amphoes) : 1,553 Km^2
Served Area (9 Amphoes) : 168 Km^2

(4) Population (At 2000 AD) :

	9 Amphoes	Development Program	Total(person)
Administrative Area :	694,629	295,496	990,125
Served Area :	363,900	442,006	805,906
Population Served :	273,725	442,006	715,731

(5) Water Demand (Maximum Daily Water Demand)

9 Amphoes : 77,800 CMD
8 Development Programs 171,750 CMD } Total 249,550 CMD

(6) Water Sources (At 2000 AD) :

Well : 42,900 CMD
Central System : 206,650 CMD } Total 249,550 CMD

(7) Daily Water Demand per Capita (At 2000 AD) :

(Unit : Liters per day)

Item \ District:	Nong Khaem	8 Amphoes (excluding Nong Khaem)
Average Daily Water Demand per Capita :	200	147
Maximum Daily Water Demand per Capita :	300	220
Maximum Hourly Water Demand per Capita :	450	330

(8) Water Demand in Accordance with Served Area (At 2000 AD):

(CMD)

Item \ District	9 Amphoes	Others (Such as Klong Dan)	Sub-Total	Adjacent Development Area	Total
Average Daily Water Demand per Capita	45,967	5,900	51,867	-	-
Maximum Daily Water Demand per Capita	68,950	8,850	77,800	171,750	249,550
Maximum Horly Water Demand per Capita	103,425	13,275	116,700	-	-

2-4-2 Comparison of Alternative Plans :

The proposed service area of the separate system is an area which spreads far and wide around Bangkok. This served area is divisible into two types of districts: one being the Amphoe town which has a long history as a community, and the other where housing and industrial development projects are being planned.

It chiefly depends on the water source whether this service area can be supplied with clear, enough amount and inexpensive water. The water sources considered for the separate system include ground water, surface water (river and Klong) and water diverted from the central system, but each source has its own advantages and disadvantages. The service area of the separate system was divided into the right and left banks of the Chao Phraya river and six alternative cases for each bank were considered so as to make an optimum choice among the water sources.

The rough estimations of Basic construction cost of all the alternative cases considered are shown in Table 2-4. The least costly combination is as follows : (See Table 2-5)

Right bank :	Case 4	406,936,000 ฿
Left bank :	Case 5	847,725,000 ฿
	Total	1,254,661,000 ฿

If the above were the choices made, the water sources would be wells and the central system for both the right and left banks.

Since M.W.W.A. has no water rights to the Klongs and rivers, the wells and central system are the only water sources that M.W.W.A. has powers to decide to tap in order to fill the demand on the separate system. The above least expensive plan is therefore within the power of M.W.W.A.

However, if water can be taken from a water treatment plant of the central system, it is necessary to adjust the Basic construction schedule of the central system and review its facilities. The preliminary investment required to do so and the increase in Basic construction cost

arising from the modification of the transmission system are not included in the estimations stated above.

The alternative plans which take second and third rank in terms of Basic construction cost are :

2nd plan	1,401,817 x 10^3 ฿
3rd plan	1,445,787 x 10^3 ฿

The Basic construction costs of these plans are only 12 to 15% more than the first least expensive plan; and these plans, which assume dependence upon the central system for 100 % or at least more than 50 % of the separate system water supply can be said to be relatively low in cost to implement.

The remaining alternative plans rank in cost as follows:

4th plan	1,795,053 x 10^3 ฿
5th plan	2,635,044 x 10^3 ฿
6th plan	2,790,309 x 10^3 ฿

Any plan to tap the river and Klong is very expensive to implement, and the Basic construction cost for the plans to tap these water sources is 1.4 to 2.2 times as high as that for the plans to divert water from the central system.

In short, the plan to rely on the central system in large measure is economically advantageous, and the plan to supply ground water and water diverted from the central system can be considered an optimum and feasible one.

However, when the plan to divert water from the central system is to be adopted, it will be necessary to make a prior review of its facilities respective to the stages of Basic construction, design and planning.

Table 2-4 ALTERNATIVES OF SEPARATE SYSTEM

Location	Case	Basic Construction Cost (1,000 ฿)	Water Sources	Cost(฿/CMD)
Right Bank (56,400 CMD)	Case 1	735,302	Well & Nakhon Chai Si River	13,037
	Case 2	873,660	Nakhon Chai Si River	15,490
	Case 3	882,309	Klong Mae Nam Om	15,644
	Case 4	406,936	Well & Central System	7,215
	Case 5	489,372	Klong Mae Nam Om & Central System	8,677
	Case 6	481,017	Central System	8,529
Left Bank (193,150 CMD)	Case 1	1,761,384	Well, Klong Sam Wa & Sip Sam	9,119
	Case 2	1,908,000	Klong Sam Wa & Sip Sam	9,878
	Case 3	956,415	Well, Klong Sam Wa & Central System	4,952
	Case 4	1,059,751	Klong Sam Wa & Central System	5,487
	Case 5	847,725	Well & Central System	4,389
	Case 6	920,800	Central System	4,767

Table 2-5 ALTERNATIVES OF SEPARATE SYSTEM

Grade	Case	Basic Construction Cost (1,000 ฿)	Percentage (%)	Water Sources (CMD)		Percentage (%)
1	Right Bank - 4	406,936		Well	42,900	17.2
	Left Bank - 5	847,725		Central	206,650	82.8
	Total	1,254,661	100			
2	Right Bank - 6	481,017				
	Left Bank - 6	920,800		Central	249,550	100
	Total	1,401,817	112			
3	Right Bank - 5	489,372		Well	31,800	12.8
	Left Bank - 3	956,415		Klong	62,450	25.0
	Total	1,445,787	115	Central	155,300	62.2
4	Right Bank - 1	735,302		Well	11,100	4.4
	Left Bank - 4	1,059,751		River	45,300	18.2
	Total	1,795,053	143	Klong	77,350	31.0
				Central	115,800	46.4
5	Right Bank - 2	873,660		Well	31,800	12.7
	Left Bank - 1	1,761,384		River	56,400	22.6
	Total	2,635,044	210	Klong	161,350	64.7
6	Right Bank - 3	882,309				
	Left Bank - 2	1,908,000		Klong	249,550	100
	Total	2,790,309	222			

2-4-3 Feasible Plans and Their Order of Priority :

M.W.W.A will have to invest an immense amount of money and a great deal of time in order to complete the central system as is presently being undertaken. The key to the successful implementation of the separate system project in parallel with the construction of the central system would be to minimize the first cost of the separate system. In addition to financing, M.W.W.A. must also solve the problem of water source; but finding a suitable water source is not totally impossible.

In the light of this way of looking at this question, the plan to supply groundwater to the 8 Amphoes should be discussed first of all. The separate system is required to supply not only the 8 Amphoes but also Nong Khaem and the adjacent development area where housing and industrial development projects are planned. There is no source of groundwater to tap in the district of Nong Khaem. Therefore the adjacent development area cannot possibly be supplied water as early as required amount. The budget and water sources being limited, the order of priority should be established in the supply of water. If this principle is to be respected, the groundwater supply system to the 8 Amphoes shall be an emergency program which could be initiated immediately and most expeditiously carried out.

As pointed out in the foreword, the plan to supply groundwater to the 8 Amphoes does require further survey before it can be undertaken but in spite of that, it can be considered most feasible.

On the other hand, to implement a long-term, comprehensive water supply project to cover not only the 8 Amphoes but also Nong Khaem and the adjacent development area, an investigation required to study the possibility of diverting water from the central system should be carried out in parallel with the survey for the emergency program. As the diversion of water from the central system can be decided by M.W.W.A. and at its own discretion without being consulted by other government agencies or authorities, it would take relatively little time to put its decisions into action. As the survey and data analysis required to study the possibility of diverting water from the central system should be carried out by consulting the existing data along with

the progress of the construction work of the central system, it is recommended that the survey and analytical work be undertaken not on a consultant basis but on an expert basis, because experts would be usually able to stay in Thailand for a longer period of time.

If the diversion of water from the central system is found not to be feasible, exploration should be started immediately in order to find a new source of surface water. Since this exploration cannot be made without prior consent with other government agencies or authorities, necessary agreement should be obtained among the parties concerned. As it seems likely that the exploration for a new source of surface water will chiefly consist of consulting the information and data which other government agency or authorities have accumulated, experts will lead the exploration.

The procedure for arriving at an optimum and feasible plan of a water supply is clearly shown in the flow chart of separate system project implementation as shown in Fig. 2-5, following herein. In sum, the order of priority of the feasible plans discussed above is as follows:

1) Plan to carry groundwater to the 8 Amphoes;

2) Plan to divert water from the central system; and

3) Plan to tap a new source of surface water.

On the other hand, the priorities respective to the existing 9 Amphoes are as summarized under Table 2-6.

As shown, Amphoes Nong Khaem is considered to require first priority for the implementation of the water supply, and by reason of fact that The Phra reservoir, which belongs to the central system, is being planned as a water source for this district.

Therefore, Amphoe Nong Khaem is required to be established by diverting water from the central system ahead of other served areas which are also planned to be served by diverting water from the central system.

The construction cost of the optimum and feasible plan is as shown in Table 2-7 and 2-8. The financial schedule of which is described in

detail in Sec. 8-2, and its contents is summarized as follows.

1) When the existing water charge (2.0 ฿/m^3) will never be raised in future, the balancing years of accumulated income and expenditure are all far beyond year 2000.

2) When the existing charge will be hopefully raised in future and in the most advantageous financial condition, the balancing years are shown below.

Water Charge (฿/m^3)	Case No.	Government Fund (%)	Bank OECF			Balancing Year (AD)
			Loan (%)	Interest (%)	Term of Loan	
2.5	38	50	50.0	3.25	25 Years	Beyond 2030
3.0	39	"	"	"	"	2026
3.5	40	"	"	"	"	2011

Fig. 2-5 FLOW CHART OF FUTURE STUDY IMPLEMENTATION

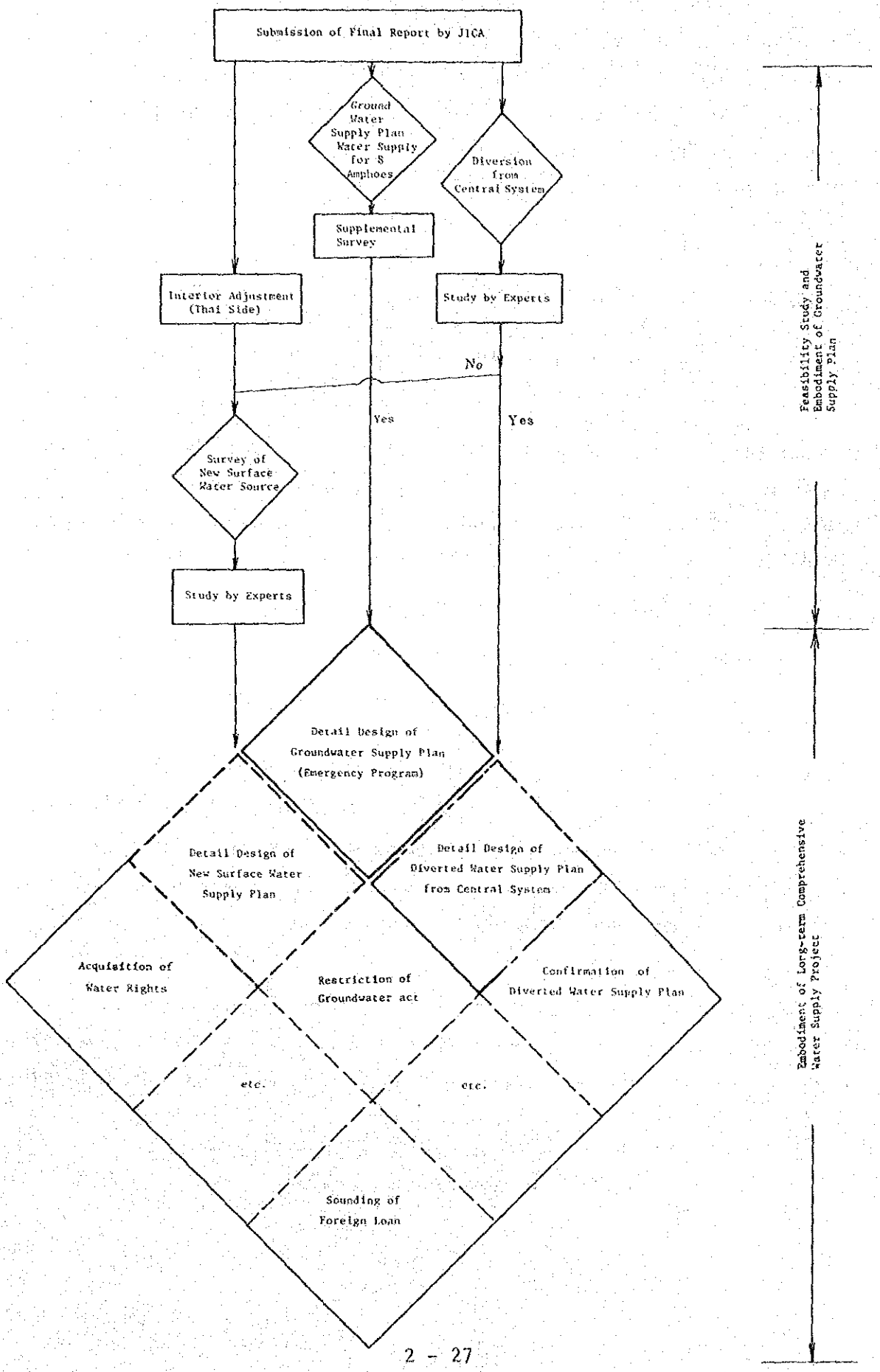


Table 2-6 ORDER OF PRIORITY FOR 9 AMPHOES

Priority	Amphoe	Water Source		Starting Year for Implementation: Emergency Stage	Stage 1	Stage 2	Stage 3	Total	Reason of Priority
1	*Nong Khaem	Central System	Yc	1981	1987	1993	-		1) Groundwater in this district is poor from the standpoint of water quality. Although people have suffered from shortage of water due to lack of groundwater, it is not possible to make a water supply plan which relies on a water source of groundwater in this district in future. 2) As the Housing and Development project of Bang Khun Thian nearby this district is already starting, construction of a water supply system is needed as soon as possible. 3) As this district holds good promise of becoming one of the main satellites of Bangkok, the operating effects are great.
			Ca	22,900	11,200	11,200	-	45,300	
			C	298,884	34,383	15,818	-	349,085	
2	Lat Krabang	Well	Yc	1981	1984	1989	1994		
			Ca	4,560	1,520	1,510	1,510	9,100	
			C	52,340	13,736	10,008	7,199	83,283	
3	Min Buri	Well	Yc	1981	1986	1993	-		1) There is a large population to be served next to Nong Khaem, and this is located at the center on left bank area in separate system. 2) As rapid development of this district is expected, due to Lat Krabang Institute of Technology, the water system is needed to be in operation at an early stage.
			Ca	4,380	1,460	1,460	-	7,300	
			C	50,829	10,930	7,249	-	69,008	
4	Bang Phli	Well	Yc	1981	1984	-	-		1) In comparison with other six Amphoes,(except Nong Khaem and Lat Krabang) this district is relatively well urbanized at present time. 2) Housing and Industrial projects of Bang Chan adjacent to this district are just starting construction and urbanization is in very early stages. Therefore, while taking into account such an influence by developing progress, this is ordered as the 3rd priority.
			Ca	1,400	1,400	-	-	2,800	
			C	17,383	14,812	-	-	32,195	
5	Bang Bo	Well	Yc	1981	1984	1987	-		
			Ca	1,000	1,000	1,000	-	3,000	
			C	16,041	3,536	4,148	-	23,725	
6	Nong Chok	Well	Yc	1981	1983	1988	1994		1) In comparison with three Amphoes mentioned above, urbanization of these six Amphoes are still behind those Amphoes. 2) There does not appear to be any especially compelling factors respective to these areas which would dictate an order of priority. If a priority is to be set for these six Amphoes, it would most likely be based upon conditions of future development.
			Ca	1,890	870	870	870	4,500	
			C	27,200	9,201	4,599	5,061	46,061	
7	Bang Bua Thong	Well	Yc	1981	1985	1992	-		
			Ca	3,000	1,100	1,100	-	5,200	
			C	41,739	15,238	13,781	-	70,758	
8	Bang Yai	Well	Yc	1981	1985	1922	-		
			Ca	2,200	1,100	1,100	-	4,400	
			C	26,012	14,447	8,345	-	48,804	
9	Sai Noi	Well	Yc	1981	1989	-	-		
			Ca	500	1,000	-	-	1,500	
			C	16,872	6,589	-	-	23,461	
	Total		Ca	41,830	-	-	-	83,100	
			C	547,300	-	-	-	746,380	

NOTE : Yc : Construction Year (AD)
Ca : Planed Construction Capacity (CMD)
C : Construction Cost (1,000 ฿)

* Including Construction Cost for Bang Khun Thian Water Supply System.

Table 2-7 ESTIMATED CONSTRUCTION COST FOR SEPARATE SYSTEM

(At 2000 AD)

Water Source	Water Demand (CMD)	Construction Cost (฿)	Remarks
Well	42,900	413,953,000	(20,697,650 $)
Central System	206,650	1,048,465,000	(52,423,250 $)
Total	249,550	1,462,418,000	(73,120,900 $)
* 9 Amphoes	83,100	746,380,000	(37,319,000 $)

* Including Construction Cost for Bang Khun Thian Water Supply System

Table 2-8 BREAKDOWN OF CONSTRUCTION COST FOR SEPARATE SYSTEM

(UNIT : 1,000 ฿)

Water Source	District \ Construction Year (AD)		Existing Well	1981	1983	1984	1985	1986	1987	1988	1989	1992	1993	1994	Total	Remarks
Ground Water	Sai Noi	Ca		500							1,000				1,500	
		B.C.		14,800							5,780				20,580	
		C		16,872							6,589				23,461	
	Bang Bua Thong	Ca		3,000			1,100					1,100			5,200	
		B.C.		36,613			13,367					12,089			62,069	
		C		41,739			15,238					13,781			70,758	
	Bang Yai	Ca	1,200	1,000			1,100					1,100			4,400	
		B.C.	-	22,818			12,673					7,320			42,811	
		C	-	26,012			14,447					8,345			48,804	
	Nong Chok	Ca		1,890	870					870				870	4,500	
		B.C.		23,860	8,071					4,034				4,440	40,405	
		C		27,200	9,201					4,599				5,061	46,061	
	Min Buri	Ca		4,380				1,460					1,460		7,300	
		B.C.		44,587				9,588					6,359		60,534	
		C		50,829				10,930					7,249		69,008	
	Lat Krabang	Ca		4,560		1,520					1,510			1,510	9,100	
		B.C.		45,912		12,049					8,779			6,315	73,055	
		C		52,340		13,736					10,008			7,199	83,283	
	Bang Phli	Ca		1,400		1,400									2,800	
		B.C.		15,248		12,993									28,241	
		C		17,383		14,812									32,195	
	Bang Bo	Ca	1,000	-		1,000			1,000						3,000	
		B.C.	-	14,071		3,101			3,639						20,811	
		C	-	16,041		3,536			4,148						23,725	
	Bang Chan	Ca		5,100											5,100	
		B.C.		14,612											14,612	
		C		16,658											16,658	
	Sub Total	Ca	2,200	21,830	870	3,920	2,200	1,460	1,000	870	2,510	2,200	1,460	2,380	42,900	
		B.C.	-	232,521	8,071	28,143	26,040	9,588	3,639	4,034	14,559	19,409	6,359	10,755	363,118	
		C	-	265,074	9,201	32,084	29,685	10,930	4,148	4,599	16,597	22,126	7,249	12,260	413,953	(20,697,650 ฿)
Central System	Nong Khaem & Bang Khun Thian	Ca		22,900					11,200				11,200		45,300	
		B.C.		262,179					30,160				13,876		306,215	
		C		298,884					34,383				15,818		349,085	
	East 3 Development	Ca				25,680	12,840				12,830				51,350	
		B.C.				217,866	972				972				219,810	
		C				248,367	1,108				1,108				250,583	
	South 3 Development	Ca				82,500				27,500					110,000	
		B.C.				392,048				1,633					393,681	
		C				446,935				1,862					448,797	
	Sub Total	Ca		22,900	-	108,180	12,840	-	11,200	27,500	12,830	-	11,200	-	206,650	
		B.C.		262,179	-	609,914	972	-	30,160	1,633	972	-	13,876	-	919,706	
		C		298,884	-	695,302	1,108	-	34,383	1,862	1,108	-	15,818	-	1,048,465	(52,423,250 ฿)
Grand Total		Ca		44,730	870	112,100	15,040	1,460	12,200	28,370	15,340	2,200	12,660	2,380	249,550	
		B.C.		494,700	8,071	638,057	27,012	9,588	33,799	5,667	15,531	19,409	20,235	10,755	1,282,824	
		C		563,958	9,201	727,386	30,793	10,930	38,531	6,461	17,705	22,126	23,067	12,260	1,462,418	(73,120,900 ฿)

NOTE : Ca : Planned Construction Capacity (CMD) B.C. : Basic Construction Cost

C : Construction Cost (Incl. Administration, Engineering Fee and Contingencies)

CHAPTER 3 ESTIMATION OF WATER DEMAND

CHAPTER 3

ESTIMATION OF WATER DEMAND

3-1 General

Preliminary to the planning of any water supply project it is necessary to estimate the amount of water that is required. The estimation of water demand provides a basis for determining the type and scale of the water source and distribution facilities and designing the construction, financing and other plans.

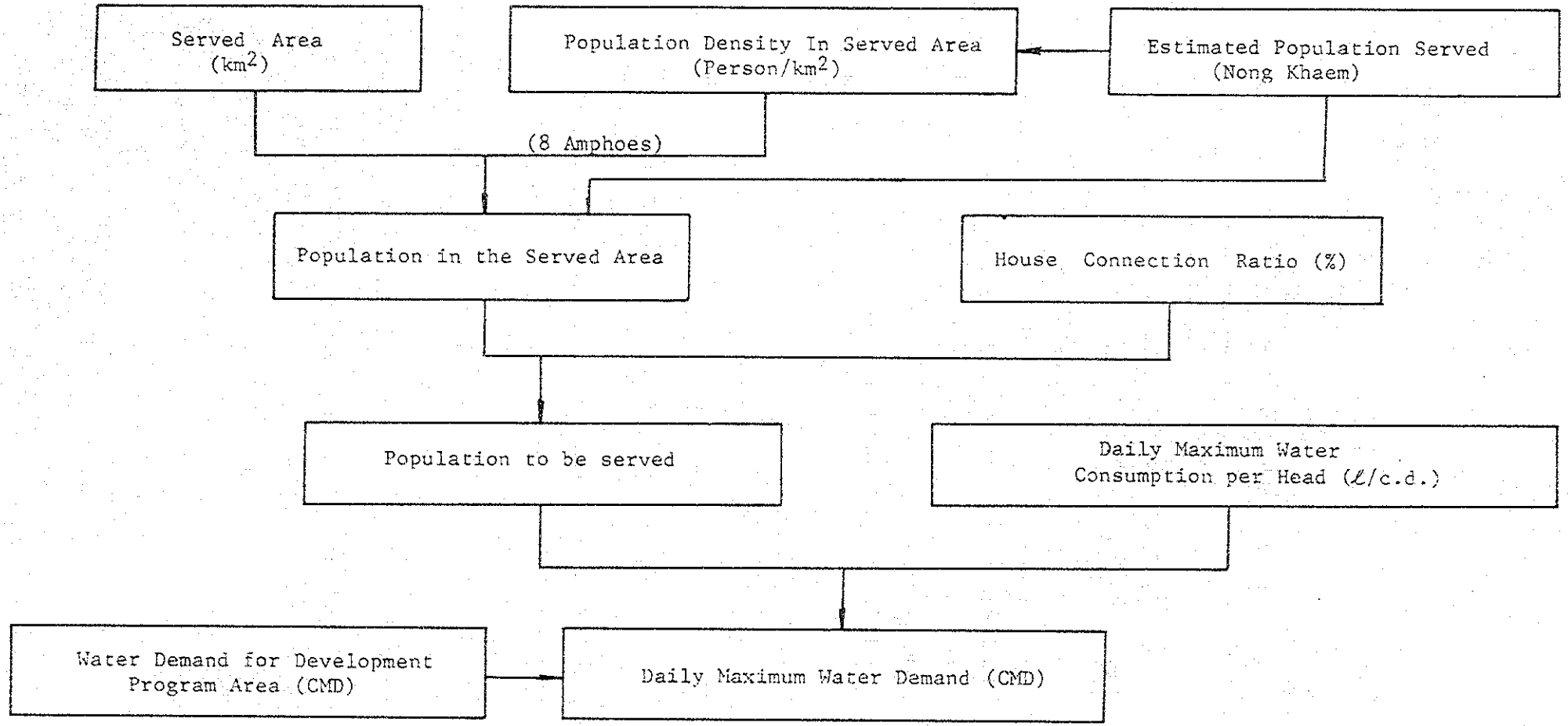
Water demand may be estimated in many ways, but in any case an appropriate choice is made among them according to the result of analysis of the water demand structure. The structure of water demand differs as a matter of course from one district to an other and is significantly influenced by the regional development of each district and the various plans for its future development.

Demand forecasting is generally done by a statistical method based upon data obtained from past records. But, if such data is not available, the record data of a comparable district is utilized.

In the present study, the information contained in the "Feasibility Study Report on the Greater Bangkok Water Supply Project",prepared by the Japanese survey team in 1973, was reviewed, and together with necessary additions and corrections made by using up-to-date information which was collected during a field survey of the project area which was carried out in a later year. On the basis of such information the basic plan of water supply of each Amphoe will be determined, and the total water demand of all Amphoes to be served and the developing environs of metropolitan Bangkok will be estimated.

The flow chart for estimation of water demand is shown in Fig. 3-1.

Fig. 3-1 FLOW SHEET FOR ESTIMATION OF WATER DEMAND



3-2 Basic Planning of Separate System Water Supply Project of Each Amphoe

3-2-1 Estimation of Populations of Administrative Districts;

(1) Methods of Population Estimation:

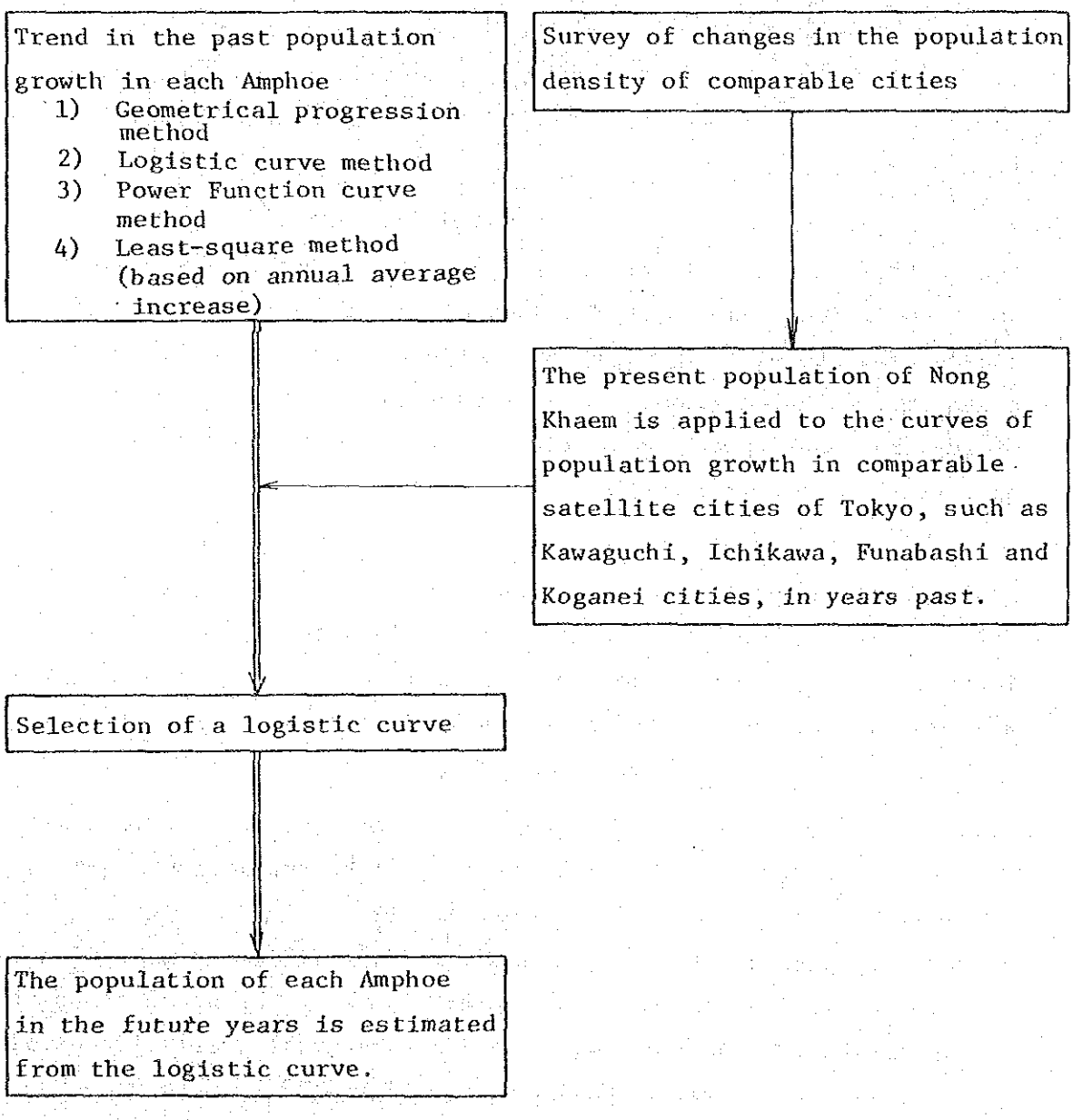
The nine Amphoes which will be served by the separate water supply system in Metropolitan Bangkok show linear development along the Klongs which drain the metropolitan area like a network. In recent years, however, there has been a marked tendency of people to move out of the almost saturated metropolitan area into the suburban districts, as roads have been built into a systematic network.

Along with the shift of population into the suburban districts, large-scale suburban development plans (such as is carried out in Lat Krabang) have been organized on the one hand and on the other not linear but radial development is taking place as in Nong Khaem. Therefore, population forecasting should not be based on the trend in population growth in years past alone, but such a new type of regional development as mentioned above should also enter into the estimation of future population.

The population of the served area is generally estimated by forecasting the future population in the corresponding administrative district on the basis of enumerations made in years past. In this study, however, the served area of all Amphoes but Nong Khaem are expected to be very small as compared with the administrative districts so that the above usual method is of no practical use.

As the populations of the administrative districts are the only data given by the city authority, the population of Nong Khaem, the sole Amphoe in which the administrative district and served area have about the same area, will be estimated according to the flow chart shown in Fig. 3-2 in this study. The populations of other Amphoes will be estimated by forecasting the population density of the served district in each Amphoe, which will be determined on the basis of the population density of Nong Khaem in 2000 in consideration of the characteristics of each Amphoe.

Fig. 3-2 FLOW CHART FOR ESTIMATION OF THE POPULATION OF THE ADMINISTRATIVE DISTRICT



(2) Population of Administrative District of Amphoe Nong Khaem :

1) Estimation of Population:

The Amphoe of Nong Khaem is located about 15 km west of the center of metropolitan Bangkok, and National Highway No. 4 runs through the center of Nong Khaem. The geographic conditions of this Amphoe favor its development as a satellite city of Greater Bangkok in the future and this Amphoe differs from others in that development is taking place in all directions as roads have been built into a systematic network, whereas in other Amphoes people generally live relatively close to the Klongs. In the case of satellites of big cities, it is difficult to estimate their future populations from only the trend in the population growth in years past. In this study, therefore, the population of a particular Amphoe for the year in question will be estimated by the trend methods which use the past data and its future population will be estimated by consulting the past data of comparable satellite cities of a big city. The population enumerations taken in Nong Khaem in years past are shown in Table 3-1.

Table 3-1 PAST POPULATION DATA

Year (AD)	Population (Person)	Increase (Person)	Increasing Ratio (%)
1966	17,000	-	-
1967	17,973	+ 973	5.7
1968	19,521	+1,548	8.6
1969	20,489	+ 968	5.0
1970	22,374	+1,885	9.2
1971	24,836	+2,462	11.0
1972	25,671	+ 835	3.4
1973	28,679	+3,008	11.7
1974	30,519	+1,840	6.4
1975	32,308	+1,789	5.9
1976	34,015	+1,707	5.3
Average			7.2

2) Population Estimation Based on Past Data:

The trend method which is employed in the population estimation has four types: geometric progression method, logistic curve method, power curve method and least square method. The future population of Nong Khaem which were estimated by the four types of trend method are presented in Table 3-2.

When the logistic curve method was employed, the saturated population (K) was assumed to be 7,000 persons/km^2 from the data of the comparable cities (Fig. 3-3).

Table 3-2 RESULT OF ESTIMATION

Method / Year (AD)	Estimated Population			
	Least Square $y = ax + b$	Power Function $y = yo + Ax^a$	Logistic Method $y = \frac{K}{1 + e^{a-bx}}$	Geometric $y = yo\ (1 + r)^x$
1980	40,815	43,533	45,649	44,890
1985	49,682	55,866	63,363	63,499
1990	58,550	69,047	85,929	89,820
1995	67,417	82,938	113,221	127,053
2000	76,285	97,443	144,223	179,719

3) Population Estimation by Analogy to Comparable Japanese Cities:

The estimation of future population based on the trend in years past may be quite in accuracy, if the city being considered is located near a big city-such as one of the nine Amphoes respective to Bangkok-as the population growth of such a smaller or sub-city can be significantly affected by the development of the big city. Thus, in efforts to account for such circumstance, the changes in the average population density of several comparable cities of Japan in years past were investigated and the data thus obtained was used to

estimate the population of Amphoe Nong Khaem in years ahead by analogy to the comparable cities of Japan.

The changes in the population density of big cities of Japan and the satellite cities of Tokyo in years past are shown in Fig. 3-3. Fig. 3-4 shows the relative locations of the satellite cities of Tokyo. As is clear from Fig. 3-3, the populations have already ceased to grow in such big cities as Tokyo and Osaka for several years. The number of residents in the heart of such big cities is even showing a tendency to decline. In their satellites, on the other hand, the population has been increasing in a sharp curve, spreading radially so that the satellites are forming second nuclei in the areas surrounding the big cities.

In some newer satellite areas the population is still growing rapidly, while in others the population is nearing saturation. In this study the cities with the population nearing saturation were selected as samples and their future population density was estimated by the logistic curve method, as shown in Figs. 3-5 and 3-6.

As will be discussed later, the administrative district of Amphoe Nong Khaem will be the same as its served area. Therefore, the method of population estimation which uses the enumerations taken in the comparable cities in other countries for years past will furnish very reliable figures for Nong Khaem. Accordingly, four Japanese cities whose growth pattern of population densities bear a close resemblance to the present counterpart of Nong Khaem were selected and their present population densities were applied to the curve for estimating the future population density of Nong Khaem. The estimations obtained by analogy to the Japanese cities are shown in Table 3-3 and compared with the estimations based on the past data in Table 3-4 and Fig. 3-7.

Fig. 3-3 POPULATION DENSITY OF JAPANESE CITIES

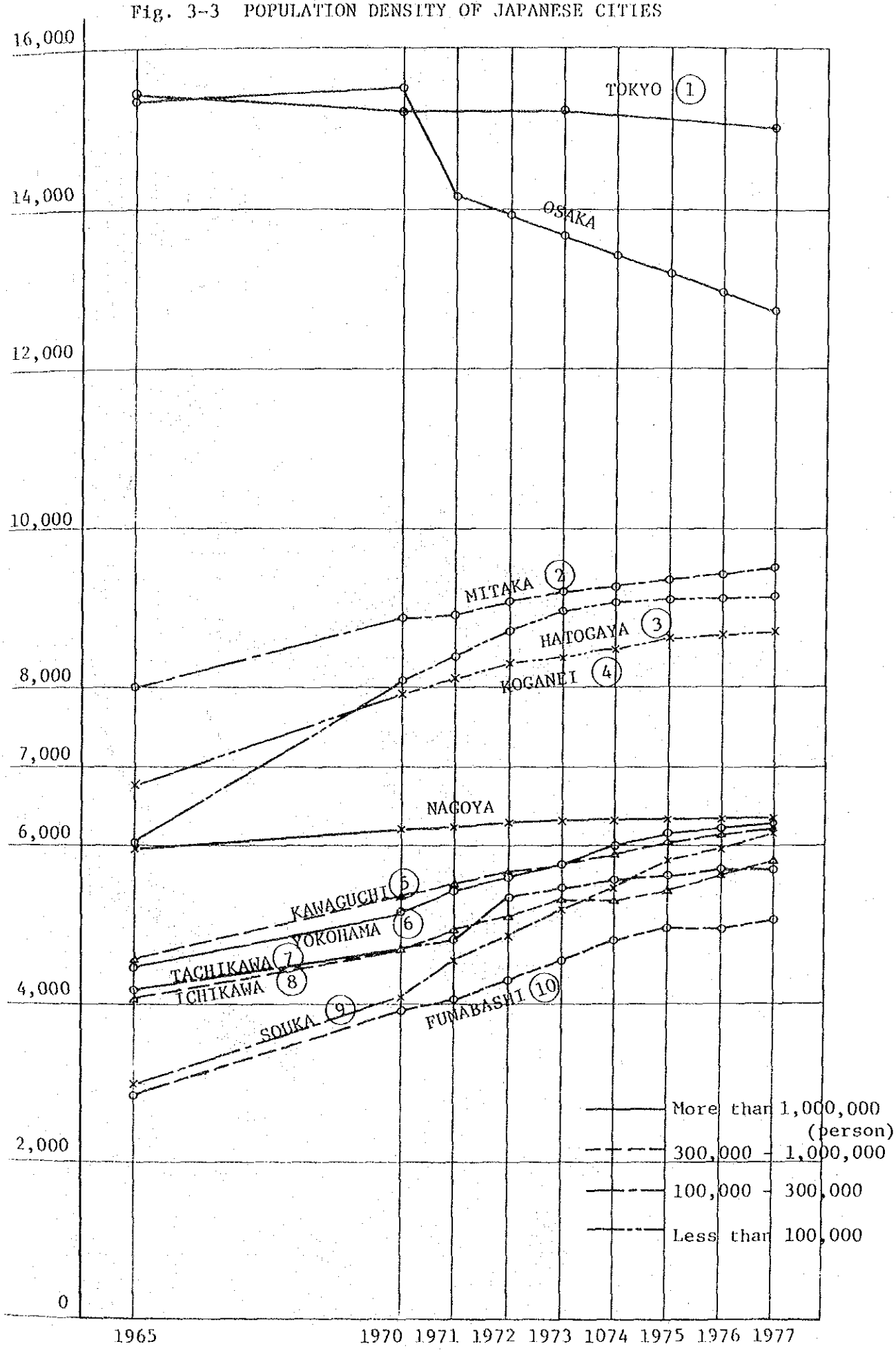


Fig. 3-4 LOCATION OF SURROUNDING CITIES OF TOKYO

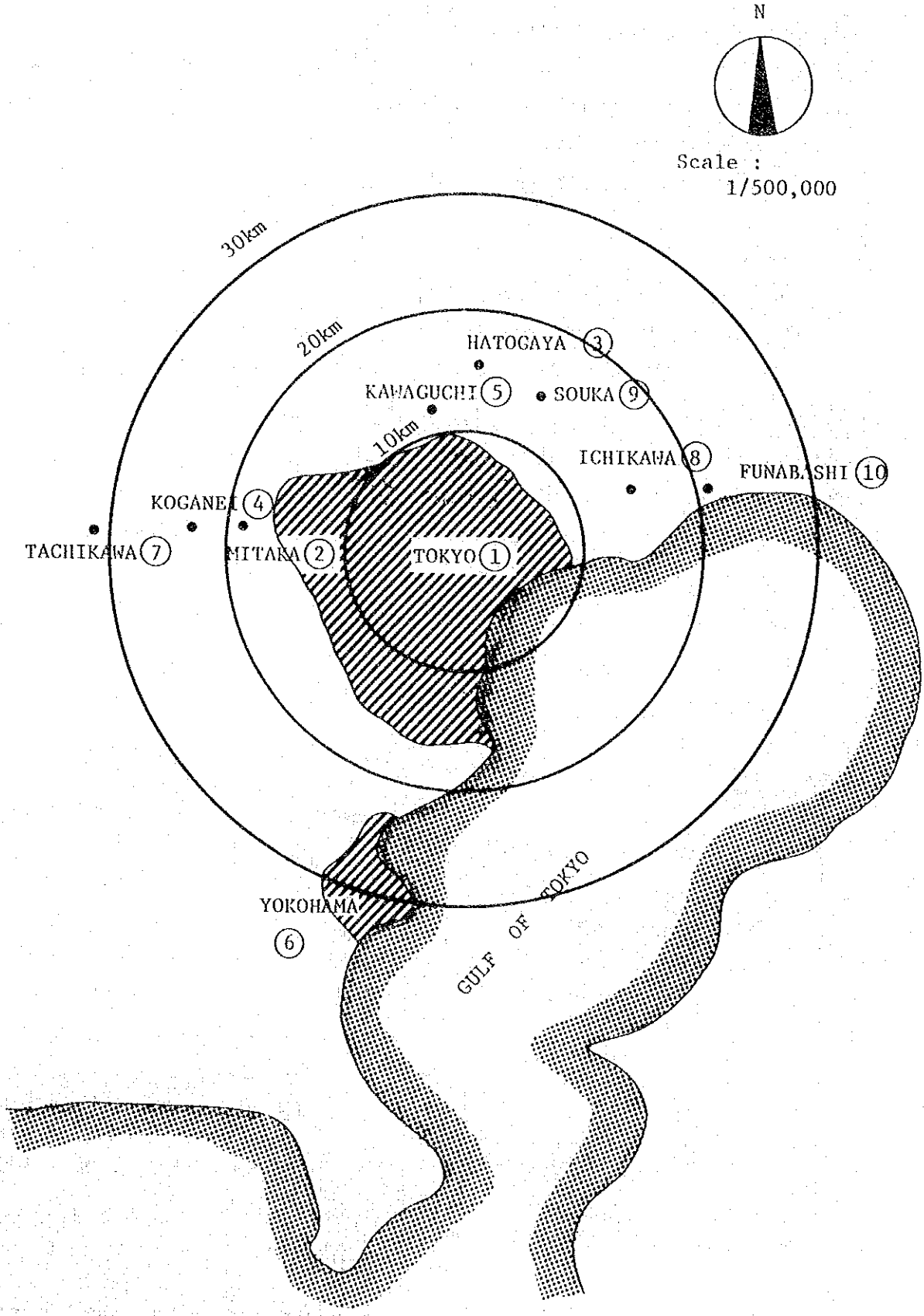


Fig. 3-5 FUTURE POPULATION DENSITY ESTIMATION AT SURROUNDING CITIES OF TOKYO

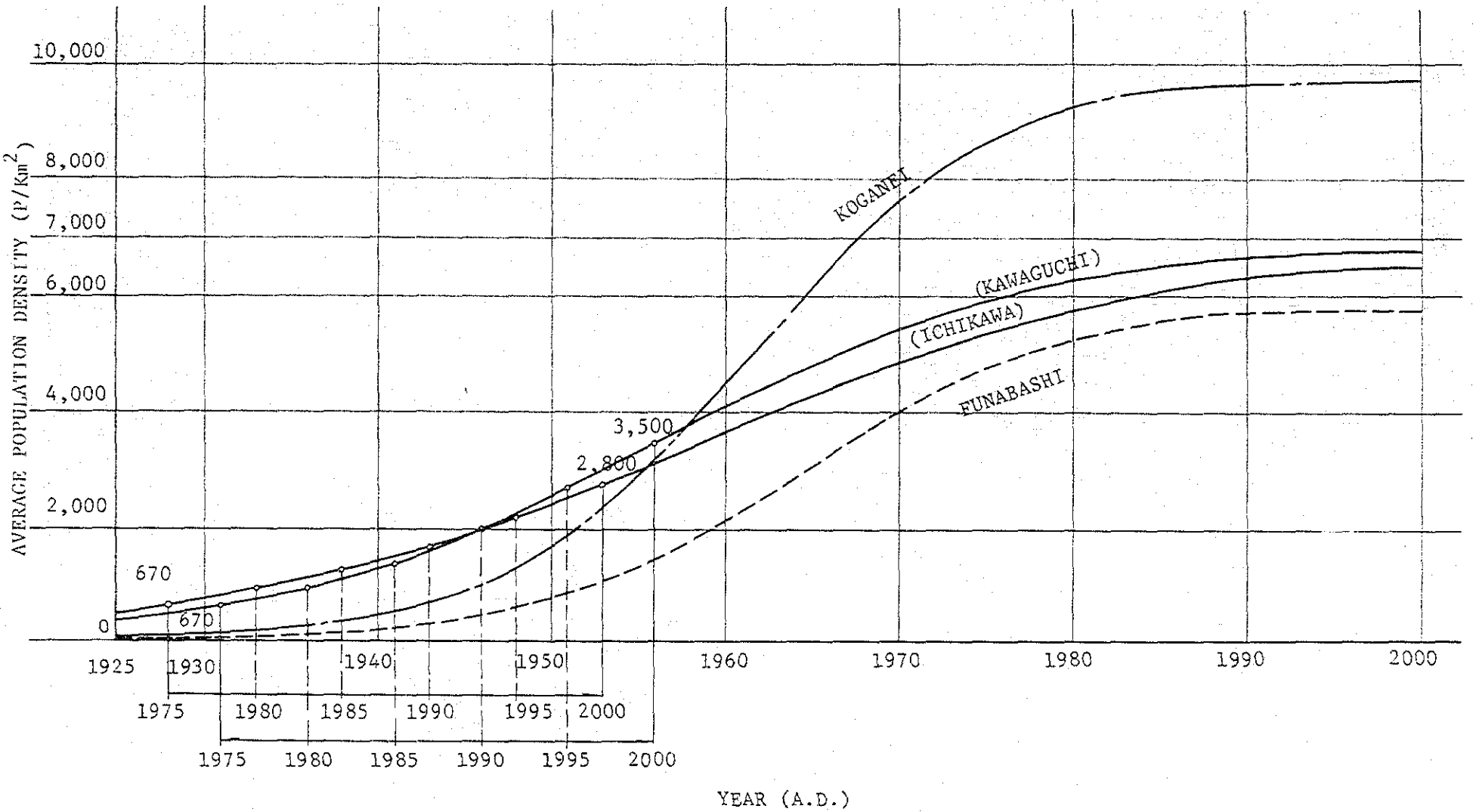


Fig. 3-6 FUTURE POPULATION DENSITY ESTIMATION AT SURROUNDING CITIES OF TOKYO

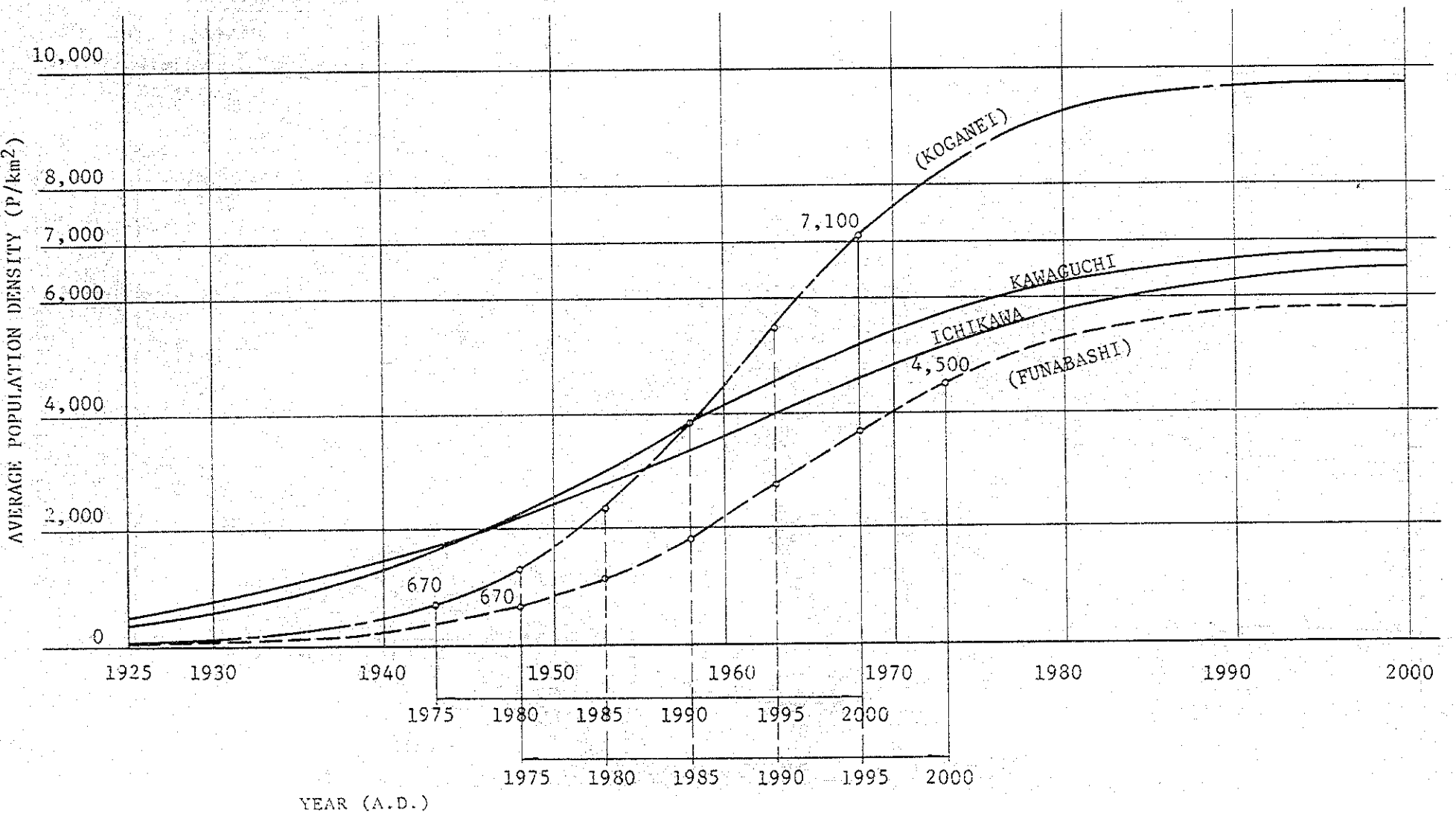


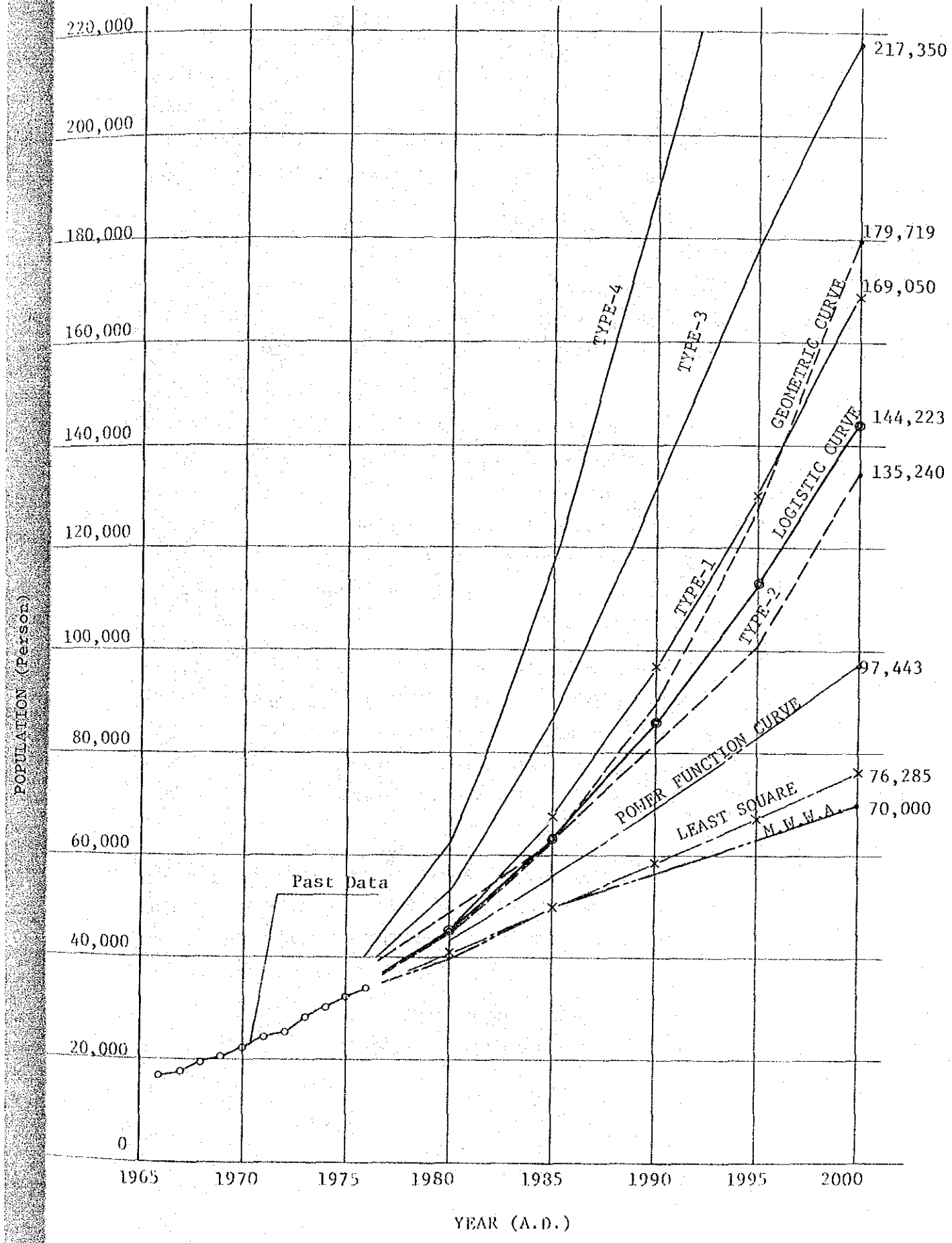
Table 3-3 POPULATION ESTIMATE OF AMPHOE NONG KHAEM
(Based On Similar Cities in Japan)

City / Year (AD)	Type -1 (KAWAGUCHI) (5)		Type - 2 (ICHIKAWA) (8)		Type - 3 (FUNABASHI) (10)		Type - 4 (KOGANEI) (4)	
	Population Density (Person/km^2)	Population (Person)	Population Density	Population (Person)	Population Density	Population (Person)	Population Density	Population (Person)
1975	670	32,308	670	32,308	670	32,308	670	32,308
1980	1,000	48,300	1,000	48,300	1,100	53,130	1,300	62,790
1985	1,400	67,620	1,300	62,790	1,800	86,940	2,400	115,920
1990	2,000	96,600	1,700	82,110	2,700	130,410	3,900	188,370
1995	2,700	130,410	2,200	106,260	3,700	178,710	5,500	265,650
2000	3,500	169,050	2,800	135,240	4,500	217,350	7,100	342,930

Table 3-4 TABLE OF ALTERNATIVE ESTIMATION FOR AMPHOE NONG KHAEM

Method / Year (AD)		Based on Past Data				Based on Similar Cities in Japan				M.W.W.A. Estimation	Remarks
		Least Square	Power Function	Logistic Method	Geometric	Type -1 KAWAGUCHI	Type - 2 ICHIKAWA	Type-3 FUNABASHI	Type-4 KOGANEI		
Estimated Population (Person)	1976	34,015	34,015	34,015	34,015	34,015	34,015	34,015	34,015	34,000	Actual Value
	1980	40,815	43,533	45,649	44,890	48,300	48,300	53,130	62,790	40,000	
	1985	49,682	55,866	63,363	63,499	67,620	62,790	86,940	115,920	50,000	
	1990	58,550	69,047	85,929	89,820	96,600	82,110	130,410	188,370	-	
	1995	67,417	82,938	113,221	127,053	130,410	106,260	178,710	265,650	-	
	2000	76,285	97,443	144,223	179,719	169,050	135,240	217,350	342,930	70,000	
Increasing Ratio (%)	1976-1980	4.7	6.4	7.6	7.2	9.2	9.2	11.8	16.6	4.1	
	1980-1985	4.0	5.1	6.8	7.2	7.0	5.4	10.4	13.0	4.6	
	1985-1990	3.3	4.3	6.3	7.2	7.4	5.5	8.4	10.2		
	1990-1995	2.9	3.7	5.7	7.2	6.2	5.3	6.5	7.1	2.3	
	1995-2000	2.5	3.3	5.0	7.2	5.3	4.9	4.0	5.2		
	Average	3.4	4.5	6.2	7.2	6.9	5.9	8.0	10.1	3.1	

Fig. 3-7 POPULATION ESTIMATION OF AMPHOE NONG KHAEM



4) Determination of Future Population of Amphoe Nong Khaem:

The minimum estimated average annual rate of population growth in Amphoe Nong Khaem is placed at 3.4 % and the maximum increase rate at 10.1 %, as shown in Table 3-4. As Nong Khaem has a close geographic relationship with Greater Bangkok, it was compared with a district which is included in Greater Bangkok.

The average annual rates of population growth in all the districts (Fig. 3-8) are estimated by MWWA as shown in Table 3-5. This shows the average annual rate of population growth for the whole Greater Bangkok area at 2.9 %; and that for district E, including Nong Khaem, at about 3.0 %, and that for district G (Samut Prakarn) at 5.1 %.

The estimated increase rate of 3.0 % for Nong Khaem seems very conservative, as compared with the minimum value of 3.4 % obtained by several methods described earlier. When the rates of population increase obtained by other methods are taken into account, it appears that greater accuracy can be attained in population estimation by adopting a value close to the maximum increase rate obtained for Samut Prakarn.

When the average annual rate of population increase is decisively estimated by the logistic method, using the data of the past years, it is 6.2 %. This result is very close to the average of 6.4 % of the corresponding values for Ichikawa city (5.9 %) and Kawaguchi city (6.9 %), cities which bear a close resemblance to Amphoe Nong Khaem.

Since Amphoe Nong Khaem holds a good promise of becoming one of the main satellites of Bangkok, it seems reasonable to expect that the population of this Amphoe will grow at an average annual rate of 6.0 % or so.

Accordingly, the future population of Amphoe Nong Khaem was estimated by the logistic curve method, as shown in Table 3-6.

Fig. 3-8 GROUPING OF AMPHOES AND CHANGWATS FOR POPULATION ESTIMATE IN THE MWWA AREA

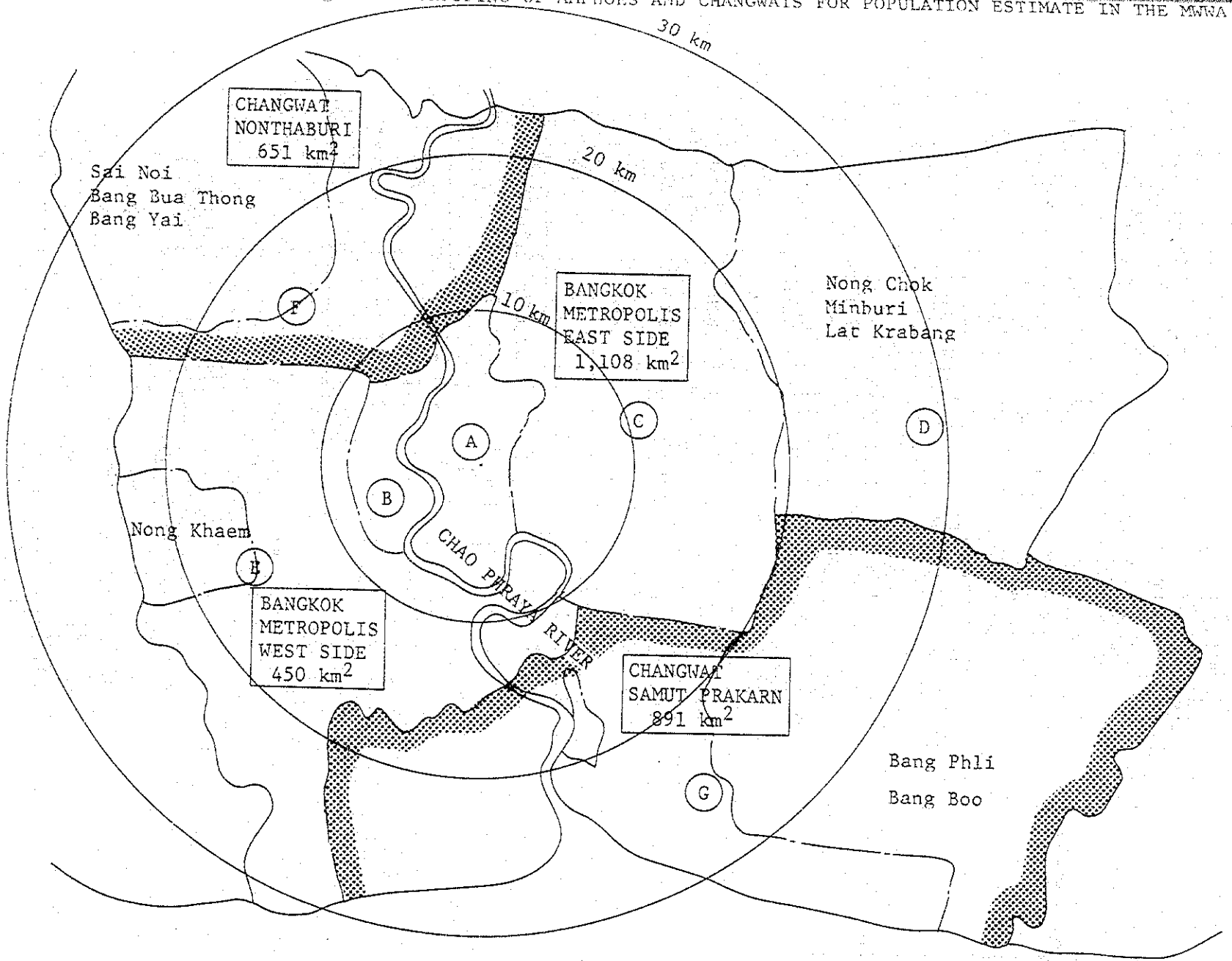


Table 3-5 POPULATION DENSITY IN GREAT BANGKOK

District	Area (km^2)	1976 (AD)		2000 (AD)		Average Increasing Ratio (from 1976 to 2000 AD)
		Population (1,000 Person)	Population Density (person/km^2)	Population (1,000 Person)	Population Density (person/km^2)	
(A)	92.69	2,062	22,246	2,970	32,042	1.53 %
(B)	43.89	846	19,275	1,310	29,847	1.84
(C)	481.15	986	2,049	2,550	5,300	4.04
(D)	534.45	130	243	330	617	3.96
(E)	405.96	535	1,318	1,090	2,685	3.01
(F)	650.45	345	530	950	1,461	4.31
(G)	890.28	447	502	1,470	1,651	5.09
(C)+(D)	1,015.60	1,116	1,099	2,880	2,836	4.03
(A)+(C)+(D)	1,108.29	3,178	2,867	5,850	5,278	2.58
(B)+(E)	449.85	1,381	3,070	2,400	5,335	2.33
(A)~(E)Total	1,558.14	4,559	2,926	8,250	5,295	2.50
(A)~(G)Total	3,098.87	5,351	1,727	10,670	3,443	2.92
Sai Noi	216.66	28	129	40	185	1.50
Bang Bua Thong	114.59	37	323	70	611	2.69
Bang Yai	96.18	31	322	40	416	1.07
Nong Khaem	48.28	34	704	70	1,450	3.05
Nong Chok	236.26	47	199	60	254	1.02
Min Buri	174.33	47	270	80	459	2.24
Lat Krabang	123.86	36	291	190	1,534	7.18
Bang Phli	323.88	70	216	270	834	5.79
Bang Bo	219.00	61	279	250	1,142	6.05

Table 3-6 ESTIMATED FUTURE POPULATION AND DENSITY IN AMPHOE NONG KHAEM

Item \ Year (AD)	1980	1985	1990	1995	2000
Estimated Future Population (Person)	46,000	63,000	86,000	113,000	144,000
Population Density (Person/km^2)	953	1,305	1,712	2,341	2,983
Increasing Ratio (%)	7.8	6.5	6.4	5.6	5.0

(3) Population of Administrative Districts of Other 8 Amphoes

It is difficult to estimate the population of the administrative districts of other 8 Amphoes, as various projects are planned there. Furthermore, the served area greatly differs in area from the administrative distict. In this study, therefore, importance will be attached to the population estimation to be served and for the administrative districts only rough estimation made by an ordinary method will be shown.

The estimation based on the past data provide the basic values to start with. However, in consideration of the fact that development is going to take place in a new area, the basic values seem to be of importance as clues which indicate the future population of the served area. In this study, therefore, the population of the administrative districts will be estimated for three cases as follows:

1) Estimations based on the past data (logistic and least square methods) :

2) Estimations from 1) to which is added the population of adjacent development area covered by this study (logistic and least square linear regression methods):

3) Estimations based on MWWA data :

These estimations were obtained through comparison with the estimations made by the Burequ of Population Census and to which was added the population of adjacent development area, and finally making corrections by way of the formula as follows:

$$Y = \frac{4C + A + B}{6}$$

wherein : A = estimation made by the arithmetic progression method

B = estimation made by the geometric progression method

C = estimation made by the least square method

The estimations obtained by the methods indicated above are presented in Tables 3-7 and 3-8 and Figs. 3-9 through 3-16.

Table 3-7 POPULATION ESTIMATE OF 8 AMPHOES (WHOLE AMPHOE)

(Person)

Amphoe / Year (AD)	Sai Noi			Bang Bua Thong		
	Least Square	Logistic Method	M.W.W.A.	Least Square	Logistic Method	M.W.W.A.
1976	-	-	28,000	-	-	37,000
1980	27,917	27,930	25,000	40,985	41,603	41,000
1985	28,598	28,615	25,000	44,916	46,628	45,000
1990	29,279	29,317	-	48,848	52,211	-
1995	29,960	30,035	-	52,780	58,402	-
2000	30,641	30,770	40,000	56,711	65,251	70,000

Amphoe / Year (AD)	Bang Yai			Nong Chok		
	Least Square	Logistic Method	M.W.W.A	Least Square	Logistic Method	M.W.W.A
1976	-	-	31,000	-	-	47,000
1980	32,756	32,814	33,000	49,968	50,257	48,000
1985	33,709	33,849	35,000	52,813	53,555	50,000
1990	34,661	34,915	-	55,658	57,061	-
1995	35,614	36,012	-	58,502	60,786	-
2000	36,566	37,142	40,000	61,347	64,743	60,000

Table 3-8 POPULATION ESTIMATE OF 8 AMPHOES (WHOLE AMPHOE)

(Person)

Amphoe / Year (AD)	Min Buri					
	① BANG CHAN (Development Program)	② Least Square	③ Logistic Method	① + ②	① + ③	M.W.W.A.
1976	-	-	-	-	-	47,000
1980	5,496	51,614	52,676	57,110	58,172	52,000
1985	5,496	57,301	60,280	62,797	65,776	60,000
1990	5,496	62,987	68,906	68,483	74,402	-
1995	5,496	68,674	78,668	74,170	84,164	-
2000	5,496	74,360	89,686	79,856	95,182	80,000

Amphoe / Year (AD)	Lat Krabang					
	① LAT KRABANG (Development Program)	② Least Square	③ Logistic Method	① + ②	① + ③	M.W.W.A.
1976	-	-	-	-	-	36,000
1980	13,640	38,877	39,602	52,517	53,242	50,000
1985	66,665	42,962	44,977	109,627	111,642	100,000
1990	130,000	47,047	51,028	177,047	181,028	-
1995	190,000	51,132	57,826	241,132	247,826	-
2000	190,000	55,217	65,445	245,217	255,445	190,000

Amphoe / Year (AD)	Bang Phli					
	① BANG PHLI-BANG BO (Development Program)	② Least Square	③ Logistic Method	① + ②	① + ③	M.W.W.A.
1976	-	-	-	-	-	70,000
1980	20,000	75,382	76,451	95,382	96,451	100,000
1985	60,000	82,272	85,198	142,272	145,198	150,000
1990	100,000	89,162	94,896	189,162	194,896	-
1995	100,000	96,052	105,635	196,052	205,635	-
2000	100,000	102,942	117,511	202,942	217,511	270,000

Amphoe / Year (AD)	Bang Bo					
	① Development Program	② Least Square	③ Logistic Method	① + ②	① + ③	M.W.W.A.
1976	-	-	-	-	-	61,000
1980	-	63,355	63,618	-	-	65,000
1985	-	66,695	67,404	-	-	70,000
1990	-	70,035	71,403	-	-	-
1995	-	73,375	75,626	-	-	-
2000	-	76,715	80,081	-	-	250,000

Fig. 3-9 POPULATION ESTIMATE - SAI NOI -
(WHOLE AMPHOE)

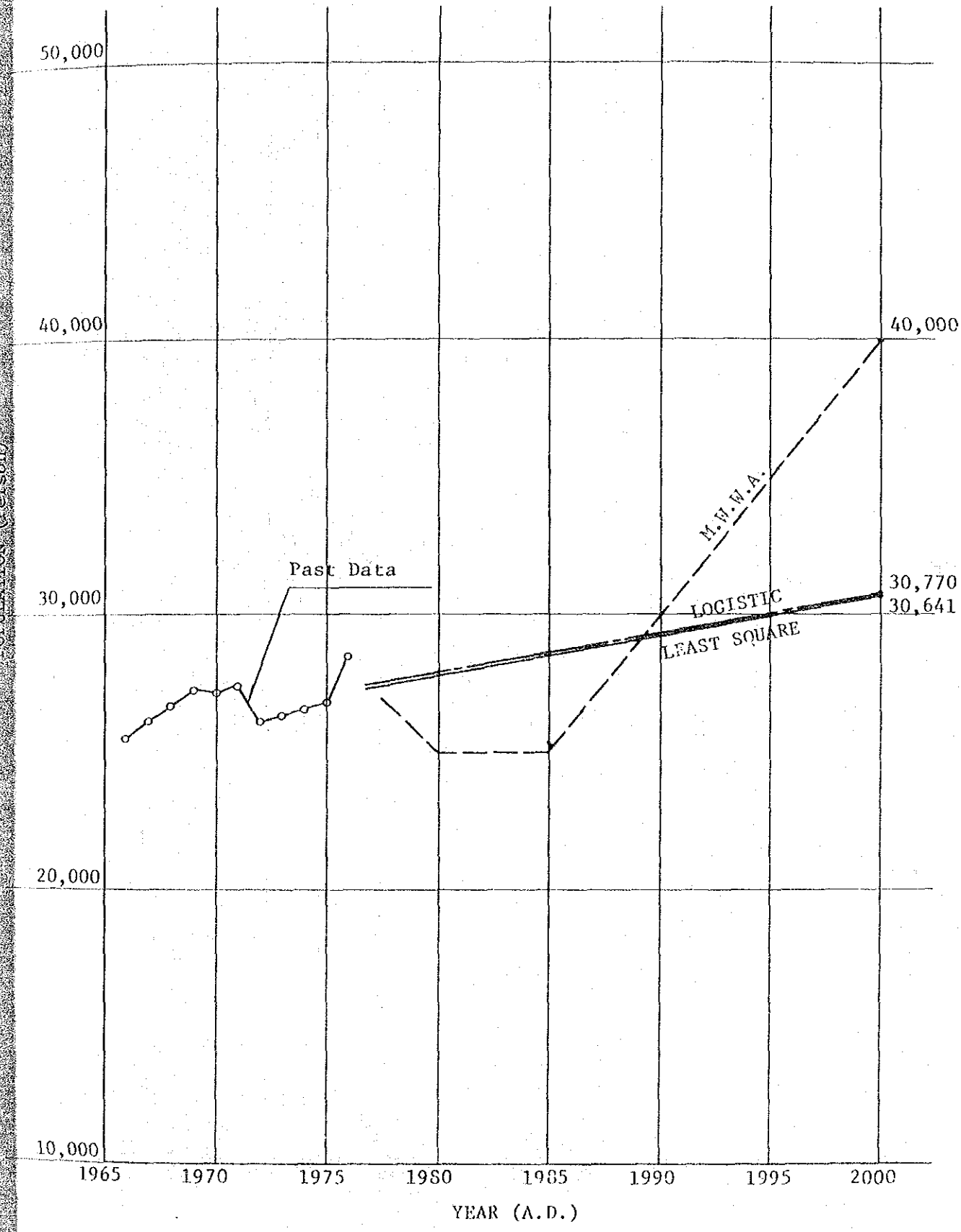


Fig. 3-10 BANG BUA THONG
(WHOLE AMPHOE)

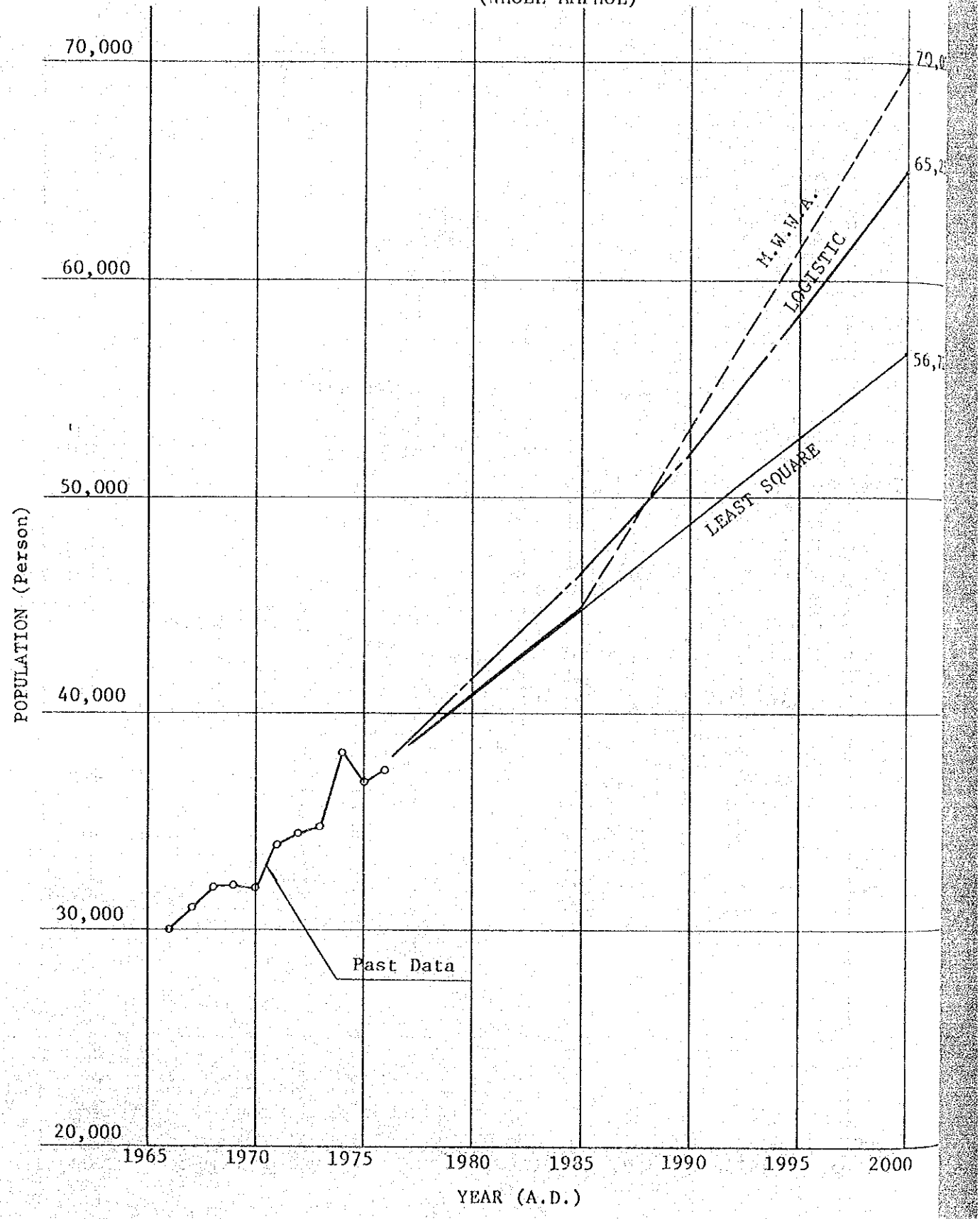


Fig. 3-11 BANG YAI
(WHOLE AMPHOE)

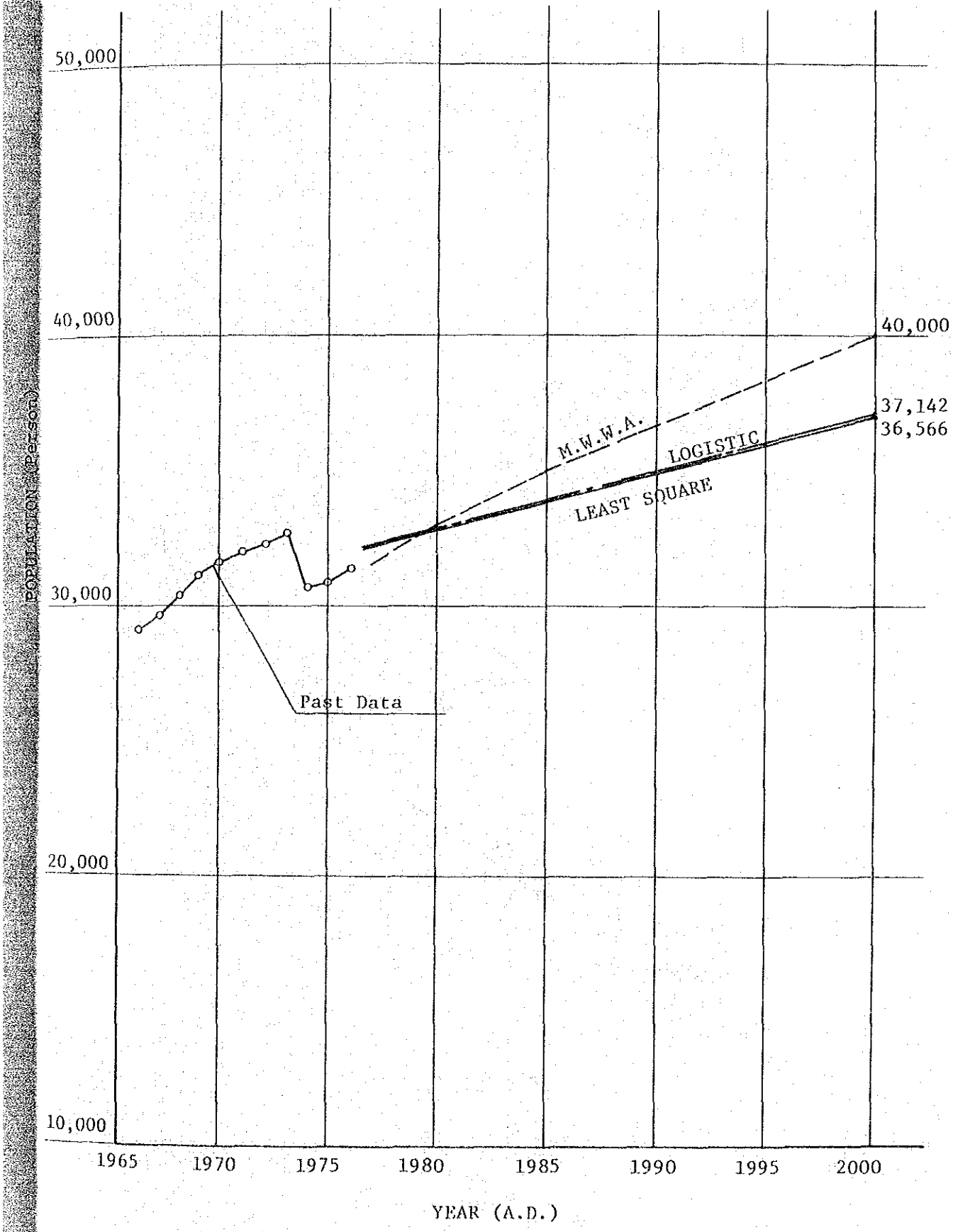


Fig. 3-12 NONG CHOK
(WHOLE AMPHOE)

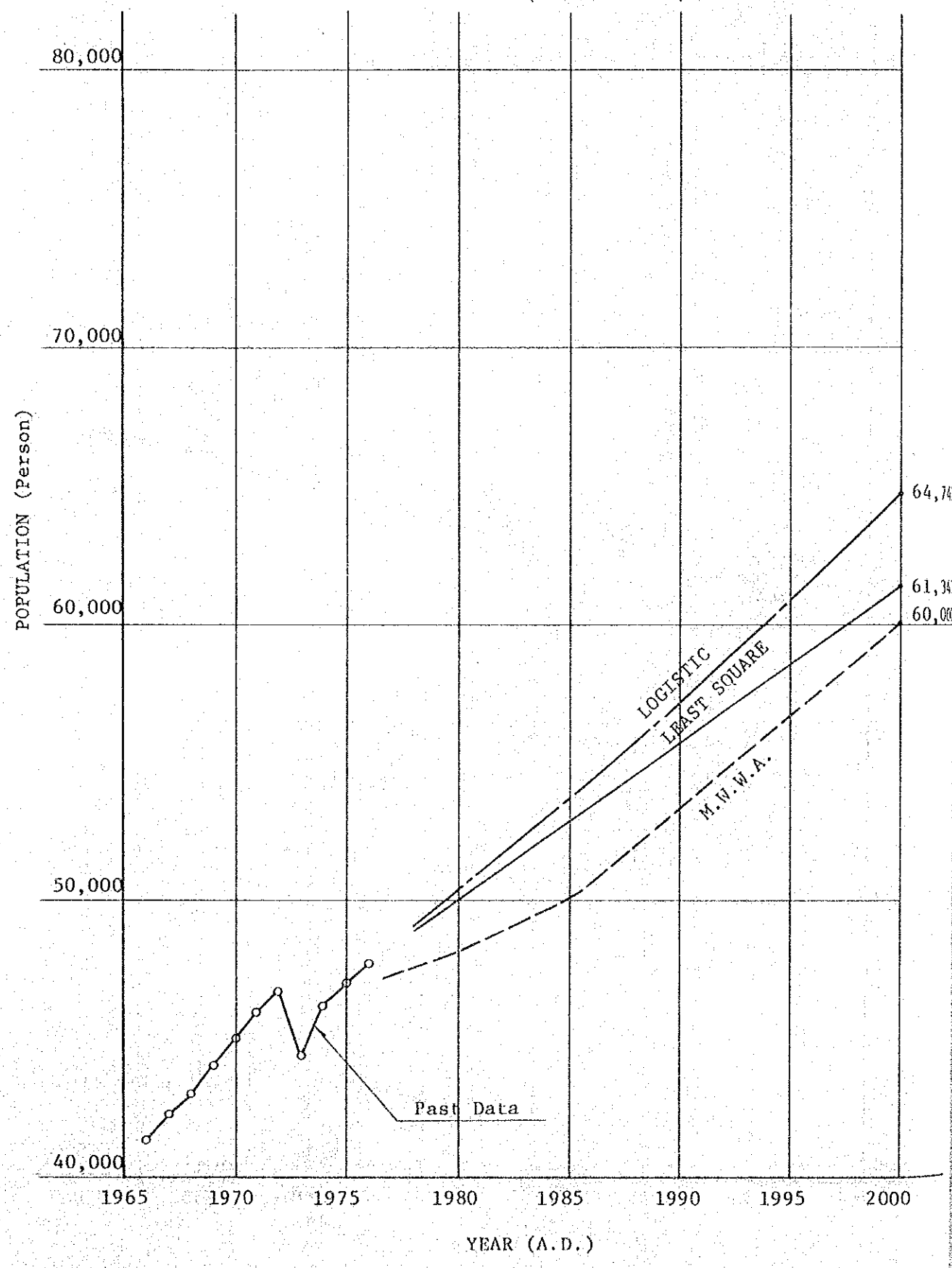


Fig. 3-13 MIN BURI
(WHOLE AMPHOE)

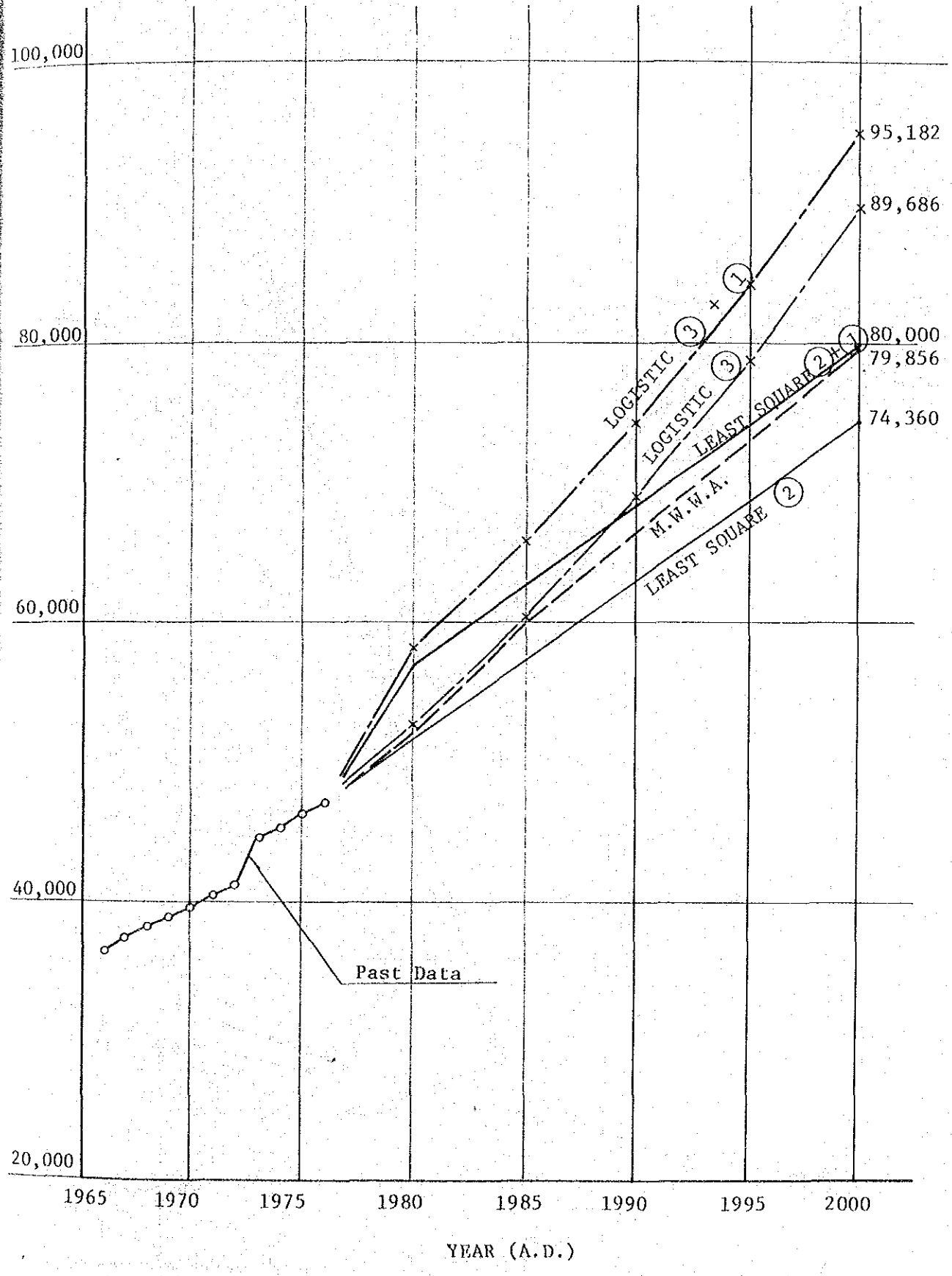


Fig. 3-14 LAT KRABANG (WHOLE AMPOE)

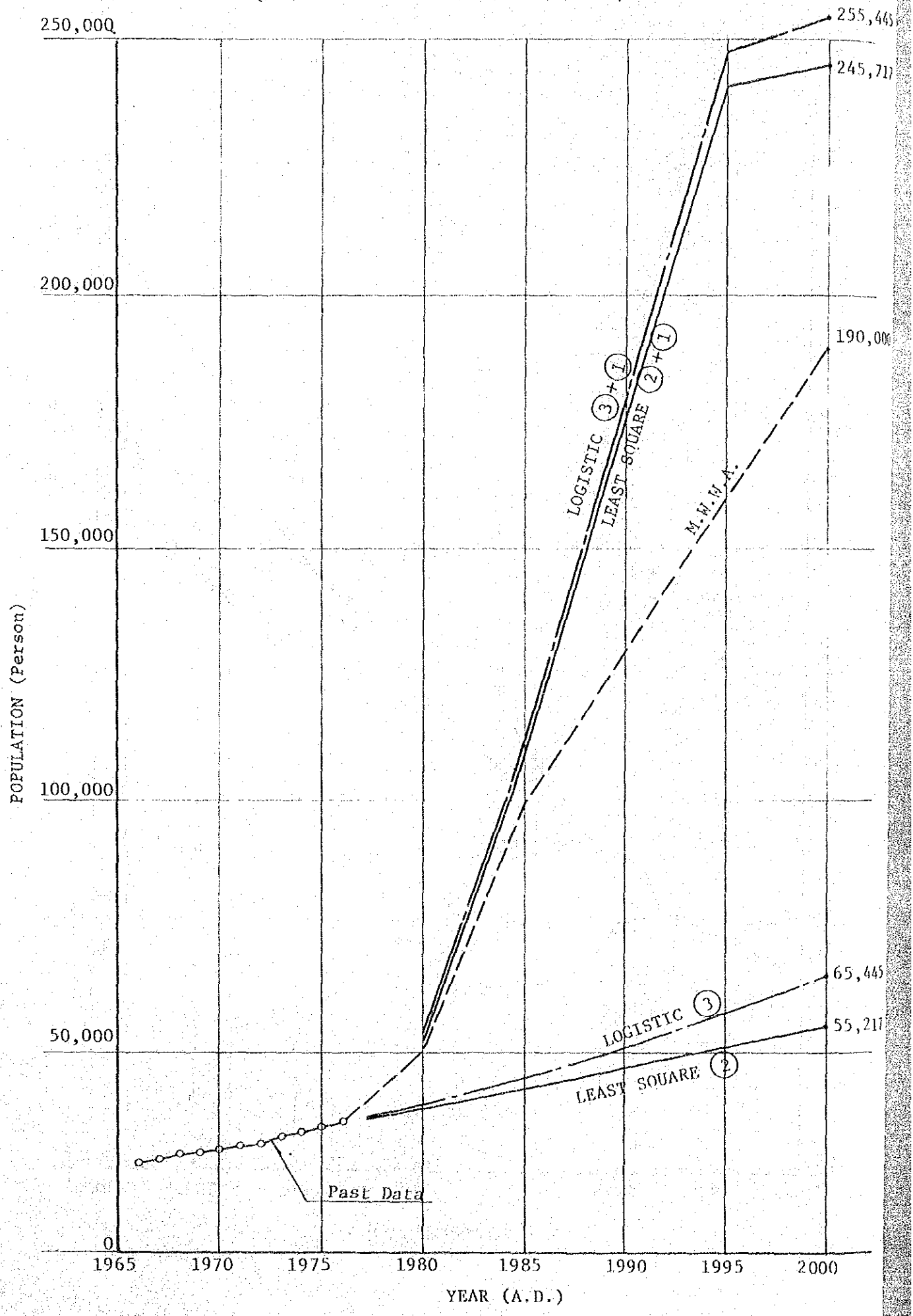


Fig. 3-15 BANG PHLI
(WHOLE AMPHOE)

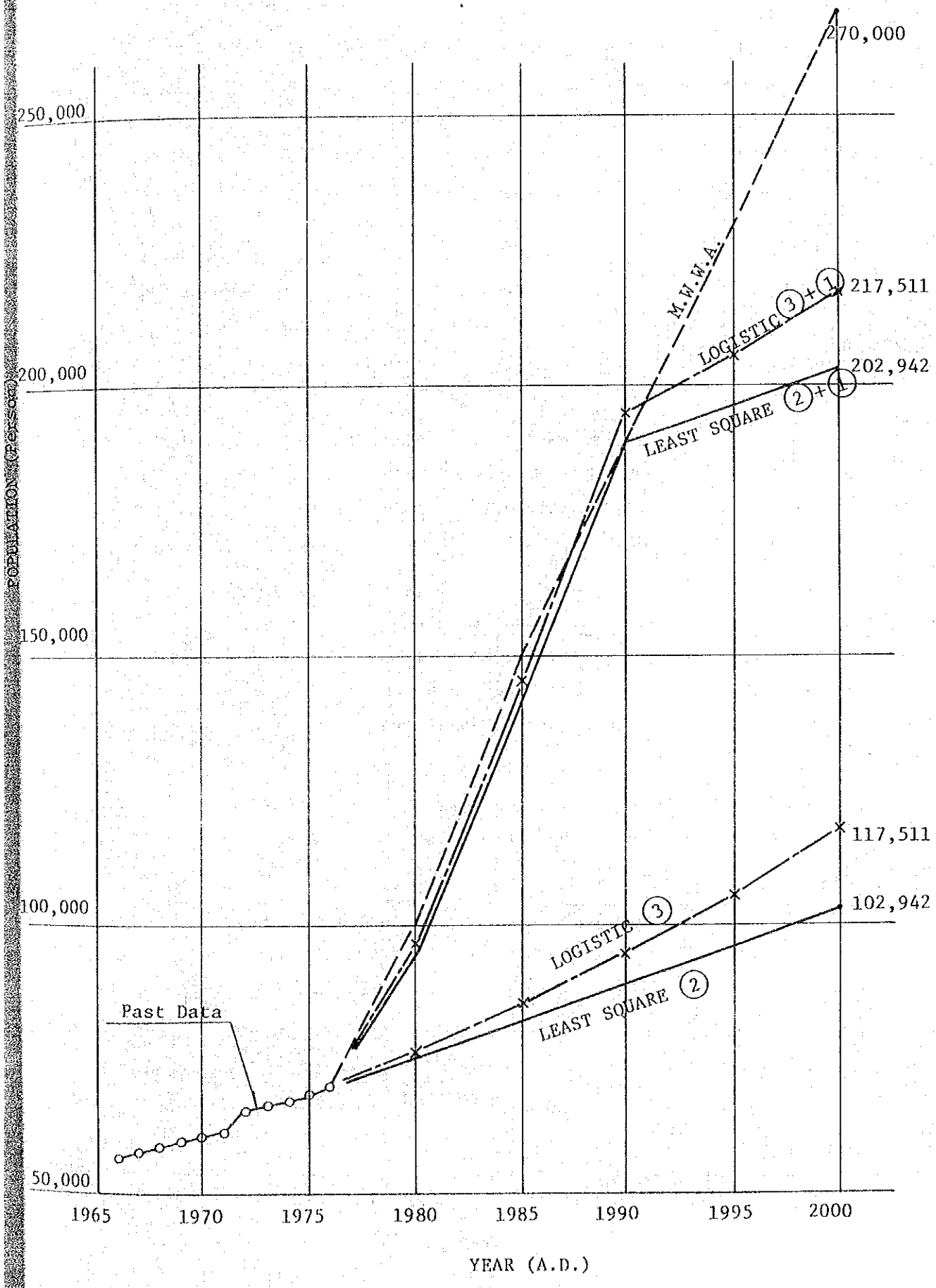
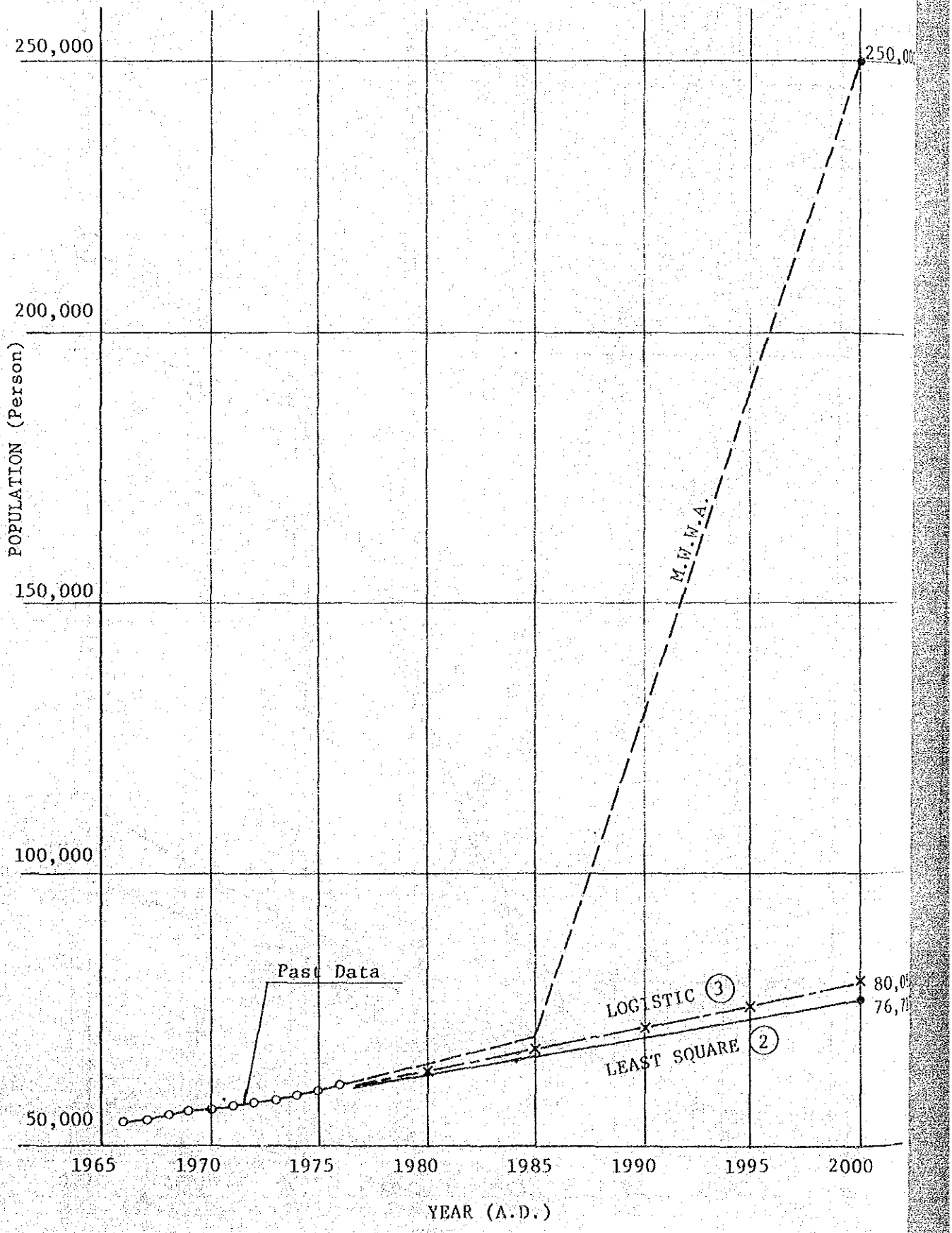


Fig. 3-16 BANG BO
(WHOLE AMPHOE)



3-2-2 Determination of Served Area :

(1) Assumptions:

The term served area refers to a district in which service pipes will have been laid by the target year. The served area should be as large as possible to serve as many people as possible. However, it will reduce the economic affect of the water supply project in large measure, if a rural districts or ones with a very sparse population are included in the served area. The served area should therefore be decided precisely in accord with the demands of each city, taking into due consideration the present population density, future regional development plans and geographic conditions of the city.

In planning the served areas of the 9 Amphoes the utilization of the Klongs and tributaries and the road conditions were important considerations. The vast majority of the population of each Amphoe live along the big Klongs and use them as their primary means of travel. Almost all district offices are located near the Klongs and around these small towns have been formed.

On the other hand, not many houses have been built along the roads thus far, but in due time people will eventually gather near the roads, especially in the suburban districts of metropolitan Bangkok. Accordingly, in anticipation of a change in population distribution, the wayside areas of both the existing and planned roads should be included in the served area.

With the above considerations in mind, the served area of this water supply project was decided based upon the following conditions:

1) The district which has already been served in included in the served area, if it is located by the Klong crossing the center of the Amphoe and is relatively densely populated.

2) The decision whether or not to include other districts in the served area is based upon consideration of the relationship of the roads to the center of the Amphoe.

3) The wayside district of big roads is in principle included in the served area to help expand the wayside zone for living.

4) The breadth of the served zones along the Khlongs and roads is decided according to the present population density or the widths of both the Klongs and roads.

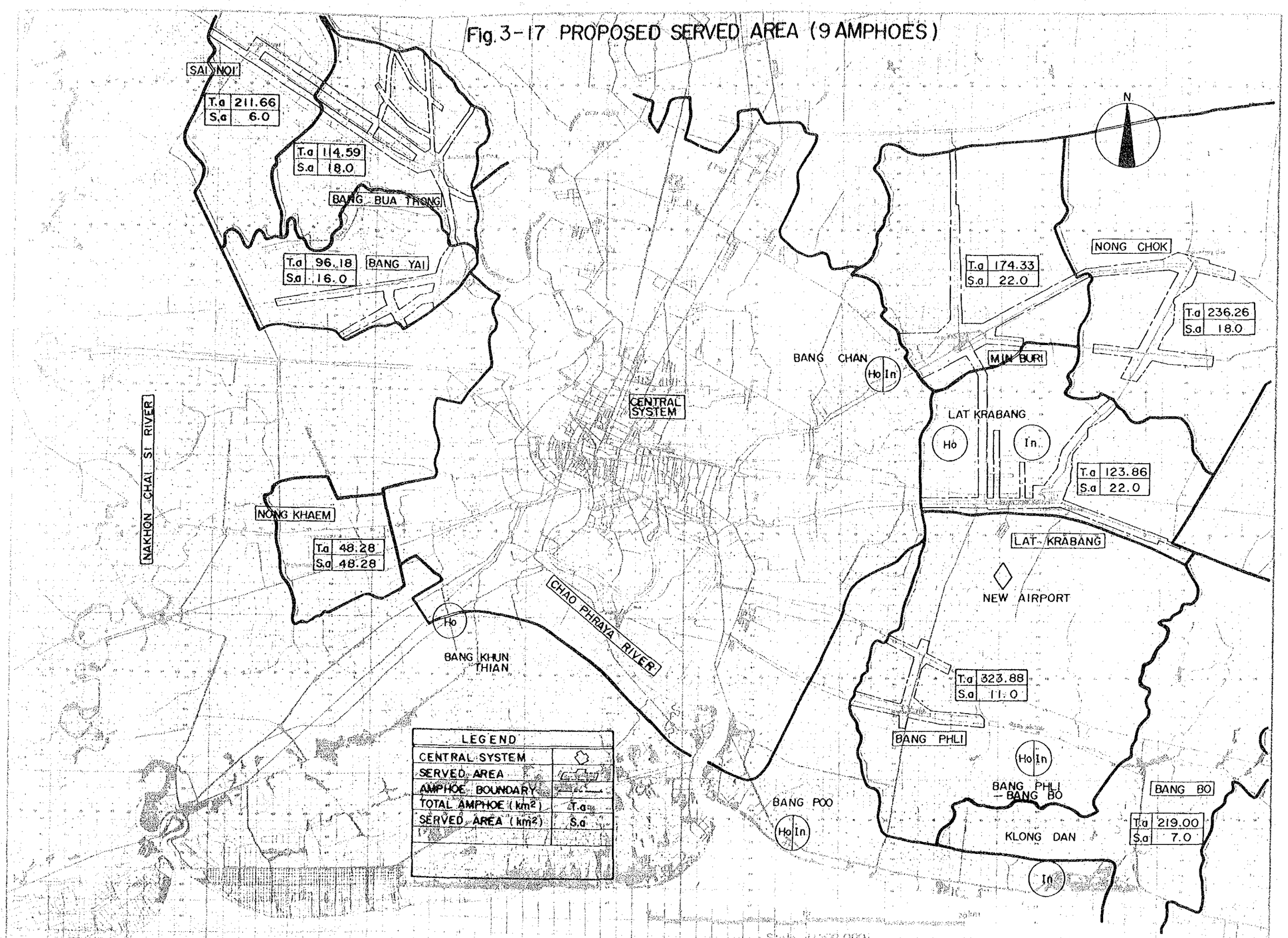
The served areas of the 9 Amphoes which were decided according to the above criteria are shown in Table 3-9 and Fig. 3-17.

Table 3-9 SERVED AREA OF 9 AMPHOES

(Km^2)

	Amphoe	Total Amphoe (at 1977 AD)	Amphoe Town (at 1969 AD)	Served Area (at 2000 AD)	Remarks
Right Bank	Sai Noi	216.66	1.0	6	
	Bang Bua Thong	114.59	1.0	18	
	Bang Yai	96.18	1.7	16	
	Nong Khaem	48.28	0.6	48.28	Whole Amphoe
Left Bank	Nong Chok	236.26	0.8	18	
	Min Buri	174.33	2.0	22	
	Lat Krabang	123.86	1.0	22	
	Bang Phli	323.88	1.0	11	
	Bang Bo	219.00	3.0	7	
Total		1,553.04	12.1	168.28	

Fig. 3-17 PROPOSED SERVED AREA (9 AMPHOES)



(2) Served Area for Each Amphoe :

1) Right Bank :

i) Sai Noi:

Amphoe Sai Noi is a rural suburban district of metropolitan Bangkok where agriculture is the chief activity of the people.

The Amphoe town is a small community which centers around the district office. The greater part of the community people live by the Klong Phra Phimon which leads to Bang Bua Thong. There is a road which runs parallel to the Klong, about 1 km north, and there are only but a few houses along this road. The served area of Amphoe Sai Noi should therefore include all the inhabited districts along the Klong Phra Phimon and the roadside district, as the latter is expected to develop as a zone for living in the years ahead because the road is the sole route connecting with the metropolitan area.

ii) Bang Bua Thong:

The main inhabited districts of Amphoe Bang Bua Thong are the one extending along the Klong from the intersection of the Klong Phra Phimon flowing from Sai Noi and the Klong Bang Bua Thong and the Amphoe town which extends from the district office located at the river intersection along the road which provides communication between Sai Noi and Bang Yai. Sparse population is also sporadically distributed along the small Klong which joins the Klong Bang Bua Thong.

Accordingly, the served area of Amphoe Bang Bua Thong should include the Amphoe town and the neighboring districts of the main Klong tributaries and roads.

The Klong Bang Bua Thong is a tributary of the Klong which joins the Chao Phraya and a and provides an important means of transportation for the people living by the Klong Bang Bua Thong and those living near the small Klong, but the population density in this district will in all probability increase in the future. The served area of this Amphoe should extensively cover the reaches of this river up to the boundary of the Amphoe.

iii) Bang Yai:

The main inhabited district of Amphoe Bang Yai extends along the Klong from the intersection of the Klong Bang Yai and the Mae Nam Om which joins the Chao Phraya river.

The population is more or less uniformly distributed along the small Klong tributaries of the two main Klongs. The district office is located at their intersection and the road which extends east from the district office divides into two roads at some distance from the district office, one of which leads to Bang Bua Thong and the other to Bangkok.

The served area of this Amphoe should therefore consist of the Amphoe town, the districts along the main Klongs and uniformly inhabited districts along the small Klong tributaries.

At present people do not live along the roads which lead to Bang Bua Thong and Bangkok, but the neighboring districts of these roads were included in the served area of this Amphoe; partly because these roads provide communication routes to metropolitan Bangkok, Sai Noi and Bang Bua Thong, and partly because these roadside districts are only short distance from metropolitan Bangkok.

iv) Nong Khaem:

The inhabited district of Amphoe Nong Khaem consists of an area which extends along the Klong Phasi Charoen which flows through this Amphoe and a residential area which has been developed north of this Klong along with the improvement of the road network.

This district is about 7 sq.km in area and is near Thon Buri of Bangkok city. Furthermore, National Highway No. 4 which passes through the center of this district affords easy access to metropolitan Bangkok. This district is now being turned into a residential area.

When the geographical limits of this district and the potential of its socio-economic development in the years ahead are taken into consideration, the whole area of this Amphoe should be served.

2) Left Bank:

i) Nong Chok:

The man inhabited area of this Amphoe centers around the district office along the Klong Saen Saep, and all other inhabited district also extend along this Klong.

The served area of this Amphoe should cover the districts which are accessible from the road which connects the center of Nong Chok to that of Lat Krabang, running across National Highway No. 304 which runs from east to west on the south of the Klong Saen Saep and the Amphoe town.

At present there are but a few houses in the districts of neighboring the two roads, but they should be included in the served area as they

hold good promise of developing into a residential area.

The tributaries of the Klongs, Klong Khut Mai, Lam Phak Chi and Lam Khaek, are not big Klongs and there are not a large number of houses in these riverside districts. However, as these districts also hold good promise of development, they should be included in the served area.

ii) Min Buri:

The population of Min Buri is concentrated in the riverside districts of the Klong Saen Saep and Sam Wa. The served area of this Amphoe should consist of the districts developed along these two Klongs and the district developed along National Highway No. 3119 which connects Lat Krabang to Min Buri and National Highway No. 304 which runs east from Bangkok.

West of the district office of Min Buri is a tract where the two national highways cross two big Klong tributaries. This tract should also be served, as it is important as a point of communication and is also but a short distance from Bangkok.

iii) Lat Krabang:

The served area of this Amphoe should consist of the most densely populated district along the Klong Phra Khanong, the roadside district of the road from Bangkok which runs east-west and parallel to the Klong Phra Khanong, and the districts neighboring on National Highway No. 3119 leading to Min Buri, the road leading to Nong Chok and the Klong Sam, Si and Pla Thiu which run north and south.

Lat Krabang occupies a leading position among the 5 Amphoes which are located in the left bank area of the Chao Phraya river, and there is a future plan to build a new airport on the south of the Amphoe town in the future. Accordingly, the district neighboring on the road leading from Bangkok should be included in the served area all the way up to the boundary of the Amphoe.

iv) Bang Phli:

In this Amphoe, population is uniformly distributed along the small Klong tributary without appreciable concentration. Also, houses are not as highly concentrated around the district office as compared to in other Amphoes. Therefore, the served area of this Amphoe should cover the districts along National Highway No. 34 which runs east-west, the Klong Samrong which flows in front of the district office, and National Highway No. 3202 which runs parallel to the Klong.

Houses are more or less regularly and uniformly distribute along both banks of the Klong Samrong, but there are only a few houses in the districts neighboring the roads. In the long run, however, the roadside districts have a greater potential for being developed as a residential area and should therefore be included in the served area. For the same reason the tracts extending on both sides of the road leading from National Highway No. 34 to the district office should also be served.

v) Bang Bo:

The inhabited area of this Amphoe has developed around the district office and at which point the Klong Bang Hia joins the Klong Samrong and extends east along the Klong Samrong.

The served area of this Amphoe should include the riverside district along the Klong Samrong and those extending along other Klong tributaries which join the Khlong Samrong, such as the Klong Phra Ong Chao Chiya Nuchit, Ban Rakat and Bang Phli Noi which already has a small population distributed over their neighboring districts. However, these districts need not be served beyond National Highway No. 34.

National Highway No. 34 runs on the north of the Amphoe town parallel to the Klong Samrong river but has little relationship with the Amphoe town of Bang Bo so that the whole roadside district of this national highway need not be served.
On the other hand, the road leading from this national highway to the district office should be served. The served area of this Amphoe should also be planned to cover the road which runs south from the district office to Klong Dan village.

Klong Dan village which is located about 8 km south of Bang Bo is directly served from Bang Bo and the water supply to the village should therefore be continued.

3-2-3. Population Density in Served Area

The population density in the planned served area of Nong Khaem in 2000 could be estimated to be about 3,000 persons/km^2, but it is extremely difficult to estimate the population density in the served area for other Amphoes, in large part because the planned served area of these Amphoes is very small. In this study, therefore, the estimations of population density in Amphoes other than Nong Khaem in 2000 were made, using the population density of Nong Khaem as the maximum value and the estimations of future population based on the past data (Tables 3-7 and 3-8) and also taking into consideration of the geographic conditions and the development of the districts surrounding the central Amphoes. The minimum population density in 2000 was assumed to be 1,500 persons/km^2 so as to operate an effective water supply in the future.

Table 3-10 POPULATION DENSITY IN SERVED AREA

	Amphoe	Population Density (person/Km^2)		Amphoe	Population Density (person/Km^2)
Right Bank	Sai Noi	1,500	Left Bank	Nong Chok	1,500
	Bang Bua Thong	1,750		Min Buri	2,000
	Bang Yai	1,650		Lat Krabang	2,500
	Nong Khaem	2,983		Bang Phli	1,500
				Bang Bo	1,500

3-2-4 Population of Served Area

The population to be served in the year 2000 can be estimated from the area to be served and the population density in the area which were determined in the earlier section, while the populations in the years before 2000 can be estimated from the enumerations made in the survey taken in 1973 and the present population of the Amphoe town by linear interpolation with the estimated population in 2000. In Nong Khaem, however, the population does not differ from the administrative to the served district so that the total population of the Amphoe was considered as the population to be served.

The estimations of population in the year up to 2000 which were made by linear interpolation with the estimated population density and population in 2000 are shown in Tables 3-11 and 3-12.

Table 3-11 POPULATION DENSITY AND POPULATION IN THE SERVED AREA

(2000 AD)

	Amphoe	Served Area (km^2)	Population Density In Served Area (person/km^2)	Population In The Served Area (Person)
Right Bank	Sai Noi	6	1,500	9,000
	Bang Bua Thong	18	1,750	31,500
	Bang Yai	16	1,650	26,400
	Nong Khaem	48.28	2,983	144,000
	Sub Total	88.28	2,397	210,900
Left Bank	Nong Chok	18	1,500	27,000
	Min Buri	22	2,000	44,000
	Lat Krabang	22	2,500	55,000
	Bang Phli	11	1,500	16,500
	Bang Bo	7	1,500	10,500
	Sub Total	80	1,913	153,000
Grand Total		168.28	2,162	363,900

Table 3-12 ESTIMATED POPULATION IN SERVED AREA UP TO 2000 AD

(Person)

	Amphoe \ Year (AD)	1972	1975	1980	1985	1900	1950	2000	Remarks
Right Bank	Sai Noi	1,180	2,000	3,400	4,800	6,200	7,600	9,000	
	Bang Bua Thong	9,406	11,800	15,700	19,700	23,600	27,600	31,500	
	Bang Yai	3,467	5,900	10,000	14,100	18,300	22,400	26,400	
	Nong Khaem	25,671	32,300	46,000	63,000	86,000	113,000	144,000	
	Sub Total	39,724	52,000	75,100	101,600	134,100	170,600	210,900	
Left Bank	Nong Chok	4,564	7,000	11,000	15,000	19,000	23,000	27,000	
	Min Buri	14,750	17,900	23,100	28,300	33,600	38,800	44,000	
	Lat Krabang	15,076	19,400	26,500	33,600	40,700	47,900	55,000	
	Bang Phli	5,144	6,400	8,400	10,400	12,400	14,500	16,500	
	Bang Bo	4,345	5,000	6,100	7,200	8,300	9,400	10,500	
	Sub Total	43,879	55,700	75,100	94,500	114,000	133,600	153,000	
Total		83,603	107,700	150,200	196,100	248,100	304,200	363,900	

3-2-5 House Connection Ratio :

The house connection ratio refers to the quotient or percent proportion of the total population of the served area as compared to the population served in that area, and is a factor which is directly concerned with the amount of water supplied.

The planned house connection ratio is affected by the present water supply condition, the hygienic sense of the community people to be served, their income level and other factors. As it is difficult to quantitatively estimate the house connection ratio, a target rate is in general practice obtained.

The living conditions and view of the water supply of the community people is generally the same from one Amphoe to the other among the nine considered for this water supply project; hence, the same house connection ratio can be assumed for all of them. The planned house connection ratio in 2000 is placed at 75 % as a target. For the intermediate years the assumption is made that the year 1980 will witness a house connection ratio of 65 % and that it will uniformly increase in all the subsequent years. The result of estimation is shown in Table 3-13.

Table 3-13 HOUSE CONNECTION RATIO

Year (AD)	1980	1985	1990	1995	2000
House Connection Ratio (%)	65.0	67.5	70.0	72.5	75.0

3-2-6 Population to be Served :

The population to be served refers to the community people who will be supplied with potable water in the year considered and is calculated by multiplying the population of the area served by the house connection ratio.

The populations to be served of all the Amphoes considered are shown in Table 3-14. As is clear from this table, Nong Khaem will

have the largest population to be served, or 108,800 persons in 2000; and Sai Noi the smallest population to be served, or 6,750 persons; while the other 8 Amphoes are expected to have much the same population to be served, or about 50,000 persons or less. A water supply system similar to the present water supply project can be operated in these Amphoes in the future.

Table 3-14 POPULATION TO BE SERVED

(Person)

	Year (AD) / Amphoe	1980	1985	1990	1995	2000
Right Bank	Sai Noi	2,210	3,240	4,340	5,510	6,750
	Bang Bua Thong	10,200	13,298	16,520	20,010	23,625
	Bang Yai	6,500	9,518	12,810	16,240	19,800
	Nong Khaem	29,900	42,525	60,200	81,925	108,800
	Sub Total	48,810	68,581	93,870	123,685	158,975
Left Bank	Nong Chok	7,150	10,125	13,300	16,675	20,250
	Min Buri	15,015	19,103	23,520	28,130	33,000
	Lat Krabang	17,225	22,680	28,490	34,728	41,250
	Bang Phli	5,460	7,020	8,680	10,513	12,375
	Bang Bo	3,965	4,860	5,810	6,815	7,875
	Sub Total	48,815	63,788	79,800	96,861	114,750
Total		97,625	132,369	173,670	220,546	273,725

3-2-7 Average Water Demand

(1) Average Daily Water Demand per Capita:

The average daily water demand per capita is one of the important factors needed to be considered when planning any water supply project. This demand varies depending upon the characteristics of the city to be served, considering such things as size of the city, its industrial structure, its culture and the living standard of its people.

When planning a new water supply project, the average daily water demand per capita is generally estimated by consulting the data of other comparable areas, and at least at the present time this method also seems appropriate for this study. It was also employed in the Feasibility Study Survey which was taken in 1973. Accordingly, the average daily water demand per capita which was estimated in the Feasibility Study Report will be adopted for this study.

In the Feasibility Study Report the data on water demand in 1959-1966 was collected in 17 cities distributed throughout Thailand and the standard yearly deviations were presented by a histogram. As a result, the following findings were obtained:

1) Averare water demand increased.

2) The standard deviation increased from year to year.

The phenomenon 1) above is only natural since the living standard of Thailanders has been improving. The phenomenon 2), on the other hand, is an indication that water demand increasingly differes from one city to the other, as the cities grow in size at differing rates. In other words, water demand varies with the size of the city so that a uniform rate of water demand cannot be appropriately applied to all of the cities distributed across the country.

According to the findings obtained above, each of the 17 cities was categorized into one of three groups as follows:

1) Cities having a served population of 50,000 or less;

2) Cities having a served population of 50,000 to 10,000; and

3) Cities having a served population of 100,000 or more.

Water consumption of each city was introduced into the equation, $y = a\sqrt{n} + b$, by the least square method in order to estimate water demand in the future. (See Table 3-15)

Table 3-15 DAILY AVERAGE WATER DEMAND PER HEAD

(ℓ/c.d.)

Class / Year (AD)	Population to be Served Less Than 50,000 Persons	Population to be Served More Than 100,000 Persons	Population to be Served Less Than 100,000 Persons
1970	117	127	150
1975	122	133	155
1980	127	140	160
1990	137	153	180
2000	147	167	200

(2) Maximum Daily Water Demand per Capita

The maximum daily water demand per capita also varies with the climate or size of the city to be served. Bangkok has little seasonal change in its climatic conditions and its average daily water demand seems to show relatively small variations. However, the Provincial Water Supply Division of the Public Works Department, Ministry of Interior, Govt. of Thailand estimates the maximum daily water demand per capita as follows:

(Maximum daily water demand per capita) = 1.5 x (Average daily water demand per capita)

As this estimate seems to indicate a reserve capacity of the water supply, the constant 1.5 will also be used in this study.

(3) Maximum Hourly Water Demand per Capita:

The previous report contained an estimation of maximum hourly water demand per capita based on the data of Sri-Racha in years past. According to it, water demand reaches a peak at PM. 7:00, up 23 % from the maximum daily consumption rate. Furthermore, the Provincial Water Supply Division of the Public Works Department, Ministry of Interior Govt. of Thailand multiplies the rate of maximum daily water consumption per capita by 150 % to obtain the rate of maximum hourly water demand per capita. In this study, therefore, the maximum hourly water demand per capita is calculated as follows:

(Rate of maximum hourly water demand per capita) = 1.5 x (Rate of maximum daily water demand per capita)

The water demand calculated by the above method is shown in Table 3-16.

Table 3-16 DAILY WATER DEMAND PER HEAD

(ℓ/c.d.)

Class	Amphoe	Item	1980 (AD)	1985 (AD)	1990 (AD)	1995 (AD)	2000 (AD)
Population to be Served more than 100,000 Persons	Nong Khaem	Daily Average	160	170	180	190	200
		Daily Maximum	240	255	270	285	300
		Hourly Maximum	360	382	405	427	450
Population to be Served less than 50,000 Persons	Sai Noi, Bang Bua Thong Bang Yai, Nong Chok Min Buri, Lat Krabang Bang Phli, Bang Bo	Daily Average	127	132	137	142	147
		Daily Maximum	190	198	205	213	220
		Hourly Maximum	285	297	307	319	330

3-3 Water Demand in Each Amphoe

The water demand in each Amphoe was estimated by using the values adopted for the basic plan of the separate system. The water demand was calculated by multiplying the population to be served by the maximum daily water demand per capita, but in the determination of water demand in Nong Khaem the water demand in its northeast district was added to the multiplier, and for Amphoe Band Bo the water demand in Klong Dan was added to the multiplier.

Results of the calculations are shown in Tables 3-17 and 3-18. The water demand in the Amphoes on the right bank in 2000 amounts to 51,100 CMD, and that on the left bank to 26,700 CMD, the total of 77,800 CMD.

The basic plan of water supply and planned maximum daily water demand of each Amphoe are shown in Tables 3-19 through 3-27 and Figs. 3-18 through 3-26.

Table 3-17 WATER DEMAND FOR 9 AMPHOES

(CMD)

	Amphoe \ Year (AD)	1980	1985	1990	1995	2000
Right Bank	Sai Noi	500	700	900	1,200	1,500
	Bang Bua Thong	2,000	2,700	3,400	4,300	5,200
	Bang Yai	1,300	1,900	2,700	3,500	4,400
	Nong Khaem	8,000	14,000	20,000	28,000	40,000
	Sub Total	11,800	19,300	27,000	37,000	51,100
Left Bank	Nong Chok	1,400	2,000	2,800	3,600	4,500
	Min Buri	2,900	3,800	4,900	6,000	7,300
	Lat Krabang	3,300	4,500	5,900	7,400	9,100
	Bang Phli	1,100	1,400	1,800	2,300	2,800
	Bang Bo	1,400	1,700	2,100	2,500	3,000
	Sub Total	10,100	13,400	17,500	21,800	26,700
Total		21,900	32,700	44,500	58,800	77,800

Table 3-18 SUMMARY OF POPULATION TO BE SERVED AND DAILY MAXIMUM WATER DEMAND FOR 9 AMPHOES

	Amphoe \ Year (AD)		1980	1985	1990	1995	2000	Remarks
Right Bank	Sai Noi	Po	2,210	3,240	4,340	5,510	6,750	
		Da	500	700	900	1,200	1,500	
	Bang Bua Thong	"	10,200	13,298	16,520	20,010	23,625	
			2,000	2,700	3,400	4,300	5,200	
	Bang Yai	"	6,500	9,518	12,810	16,240	19,800	
			1,300	1,900	2,700	3,500	4,400	
	Nong Khaem	"	29,900	42,525	60,200	81,925	108,800	
			8,000	14,000	20,000	28,000	40,000	
	Sub Total	"	48,810	68,581	93,870	123,685	158,975	
			11,800	19,300	27,000	37,000	51,100	
Left Bank	Nong Chok	"	7,150	10,125	13,300	16,675	20,250	
			1,400	2,000	2,800	3,600	4,500	
	Min Buri	"	15,015	19,103	23,520	28,130	33,000	
			2,900	3,800	4,900	6,000	7,300	
	Lat Krabang	"	17,225	22,680	28,490	34,728	41,250	
			3,300	4,500	5,900	7,400	9,100	
	Bang Phli	"	5,460	7,020	8,680	10,513	12,375	
			1,100	1,400	1,800	2,300	2,800	
	Bang Bo	"	3,965	4,860	5,810	6,815	7,875	
			1,400	1,700	2,100	2,500	3,000	
	Sub Total	"	48,815	63,788	79,800	96,861	114,750	
			10,100	13,400	17,500	21,800	26,700	
Total		Po	97,625	132,369	173,670	220,546	273,725	
		Da	21,900	32,700	44,500	58,800	77,800	

Notes : Po, Population to be served (Person)

Da, Daily Maximum Water Demand (CMD)

Fig. 3-18 BASIC PLAN - SAI NOI -

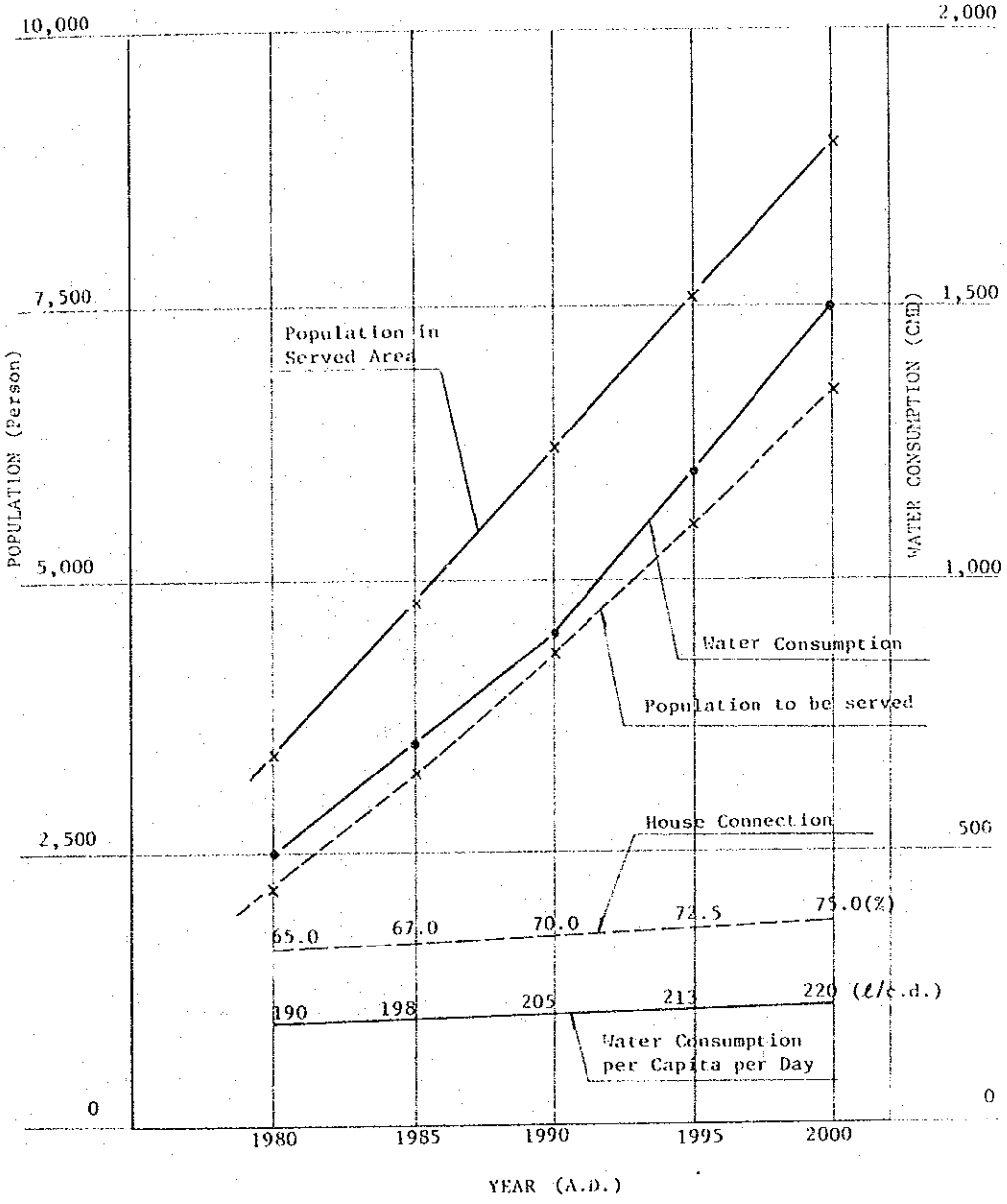


Table 3-19 BASIC PLAN - SAI NOI -

Item	Unit	1980	1985	1990	1995	2000
Population in Served Area	Person	3,400	4,800	6,200	7,600	9,000
House Connection	%	65.0	67.5	70.0	72.5	75.0
Population to be Served	Person	2,210	3,240	4,340	5,510	6,750
Daily Maximum Water Consumption per Head	ℓ/c.d	190	198	205	213	220
Daily Maximum Water Consumption	CMD	500	700	900	1,200	1,500

Fig. 3-19 BASIC PLAN - BANG BUA THONG -

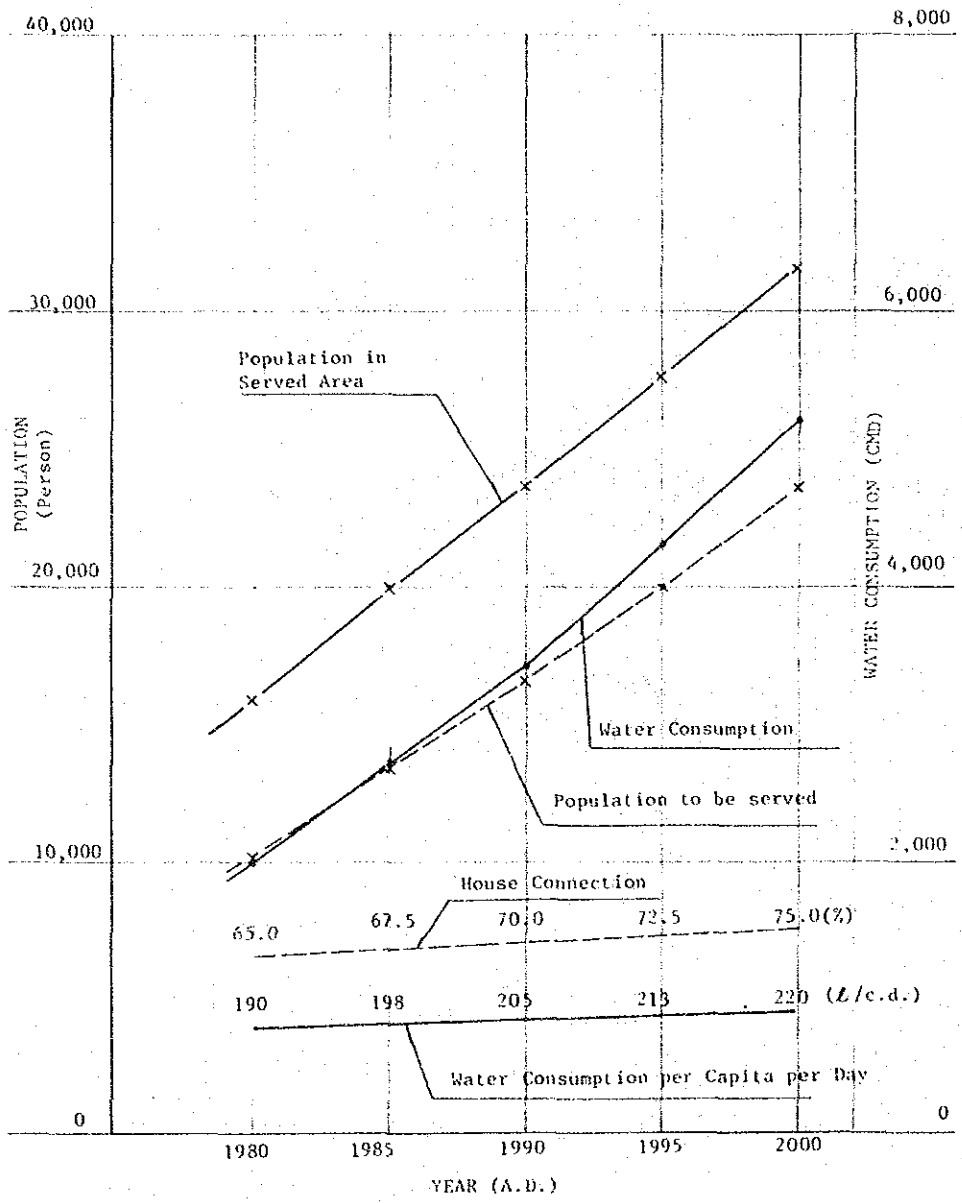


Table 3-20 BASIC PLAN - BANG BUA THONG -

Item	Unit	1980	1985	1990	1995	2000
Population in Served Area	Person	15,700	19,700	23,600	27,600	31,500
House Connection	%	65.0	67.5	70.0	72.5	75.0
Population to be Served	Person	10,200	13,298	16,520	20,010	23,625
Daily Maximum Water Consumption per Head	ℓ/c.d	190	198	205	213	220
Daily Maximum Water Consumption	CMD	2,000	2,700	3,400	4,300	5,200

Fig. 3-20 BASIC PLAN - BANG YAI -

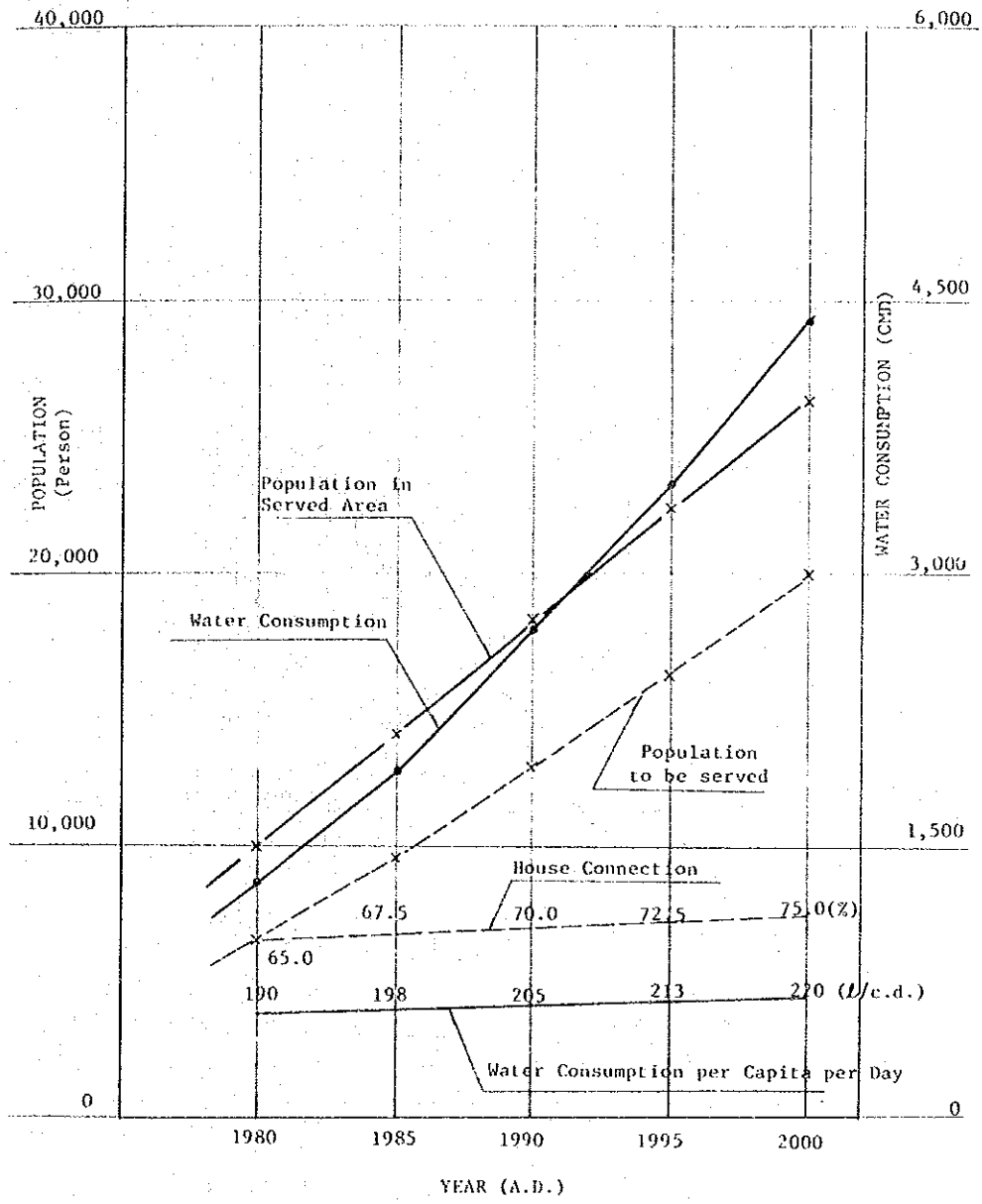


Table 3-21 BASIC PLAN - BANG YAI -

Item	Unit	1980	1985	1990	1995	2000
Population in Served Area	Person	10,000	14,100	18,300	22,400	26,400
House Connection	%	65.0	67.5	70.0	72.5	75.0
Population to be Served	Person	6,500	9,518	12,810	16,240	19,800
Daily Maximum Water Consumption per Head	ℓ/c.d	190	198	205	213	220
Daily Maximum Water Consumption	CMD	1,300	1,900	2,700	3,500	4,400

Fig. 3-21 BASIC PLAN - NONG KHAEM -

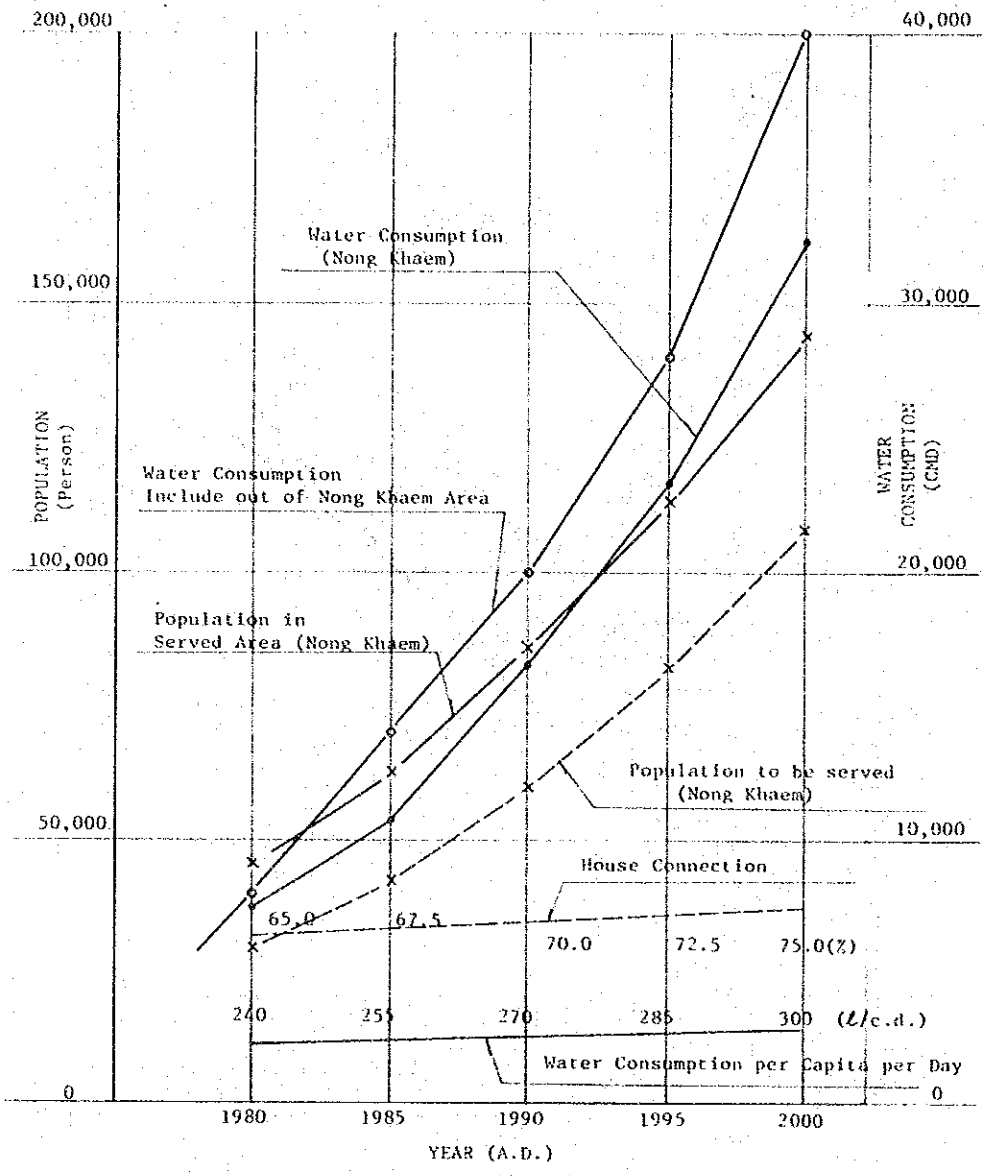


Table 3-22 BASIC PLAN - NONG KHAEM -

Item	Unit	1980	1985	1990	1995	2000
Population in Served Area	Person	46,000	63,000	86,000	113,000	144,000
House Connection	%	65.0	67.5	70.0	72.5	75.0
Population to be Served	Person	29,900	42,525	60,200	81,925	108,000
Daily Maximum Water Consumption per Head	ℓ/c.d	240	255	270	285	300
Daily Maximum Water Consumption	CMD	7,200	10,800	16,300	23,300	32,400
Out of Nong Khaem Area	CMD	800	3,200	3,700	4,700	7,600
Total	CMD	8,000	14,000	20,000	28,000	40,000

Fig. 3-22 BASIC PLAN - NONG CHOK -

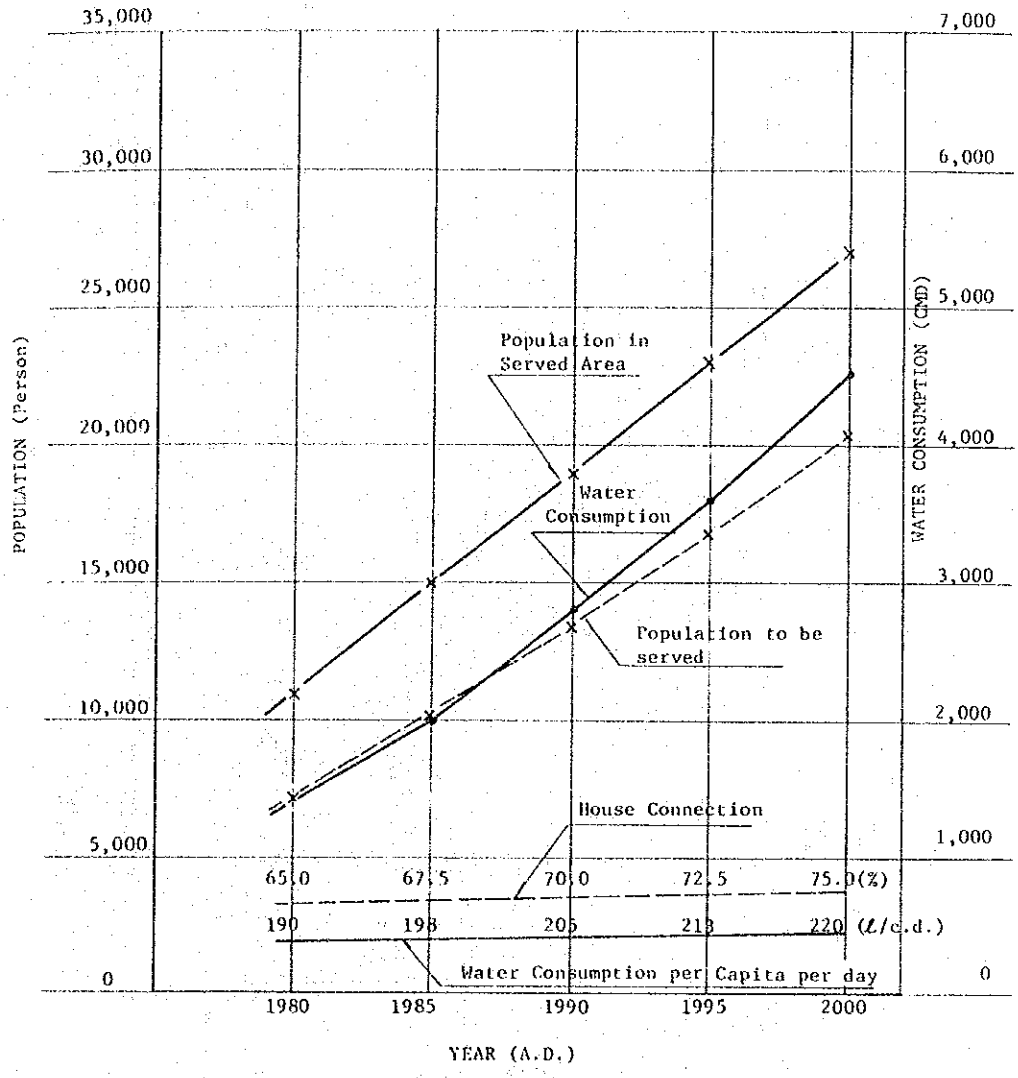


Table 3-23 BASIC PLAN - NONG CHOK -

Item	Unit	1980	1985	1990	1995	2000
Population in Served Area	Person	11,000	15,000	19,000	23,000	27,000
House Connection	%	65.0	67.5	70.0	72.5	75.0
Population to be Served	Person	7,150	10,125	13,300	16,675	20,250
Daily Maximum Water Consumption per Head	ℓ/c.d	190	198	205	213	220
Daily Maximum Water Consumption	CMD	1,400	2,000	2,800	3,600	4,500

Fig. 3-23 BASIC PLAN - MIN BURI -

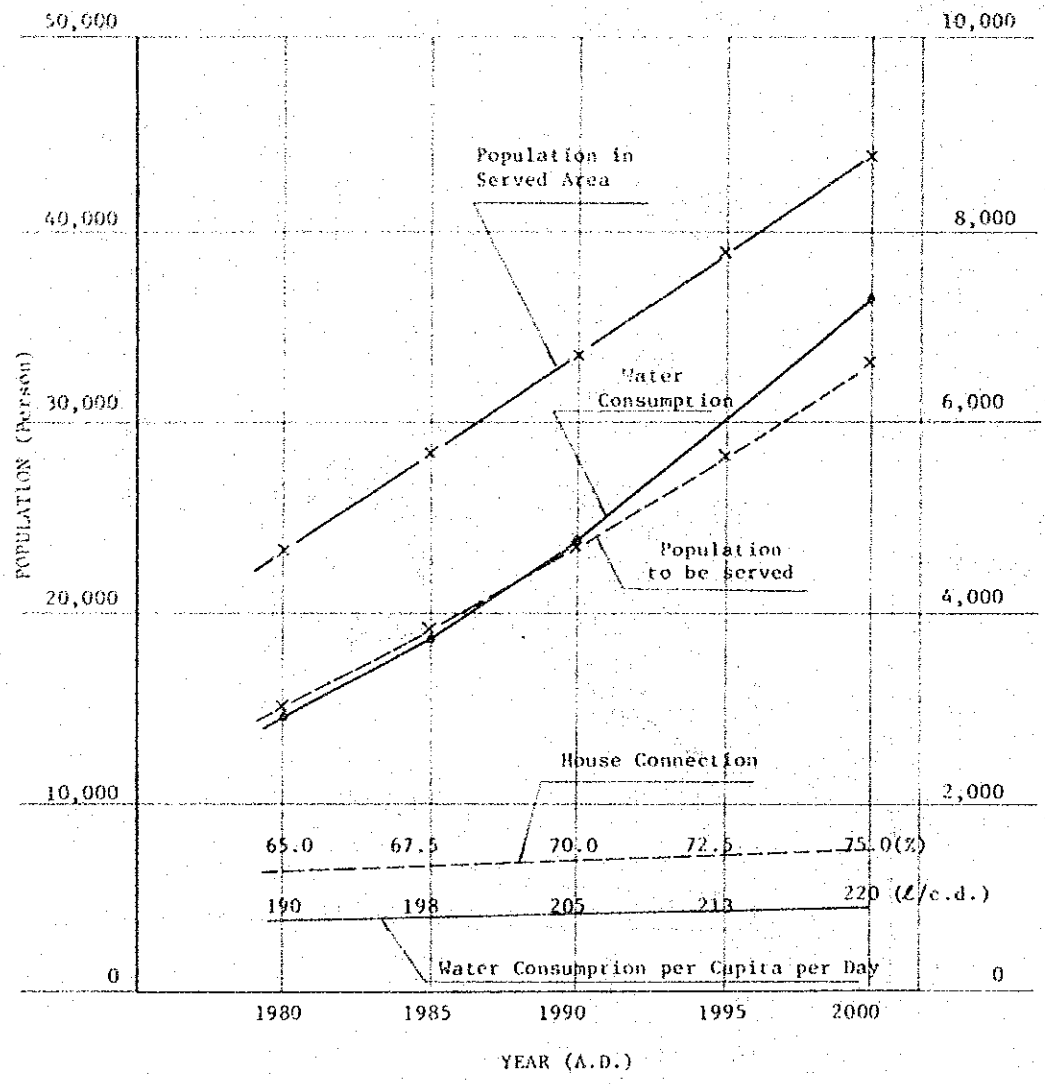


Table 3-24 BASIC PLAN - MIN BURI -

Item	Unit	1980	1985	1990	1995	2000
Population in Served Area	Person	23,100	28,300	33,600	38,800	44,000
House Connection	%	65.0	67.5	70.0	72.5	75.0
Population to be Served	Person	15,015	19,103	23,520	28,130	33,000
Daily Maximum Water Consumption per head	ℓ/c.d	190	198	205	213	220
Daily Maximum Water Consumption	CMD	2,900	3,800	4,900	6,000	7,300

Fig. 3-24 BASIC PLAN - LAT KRABANG -

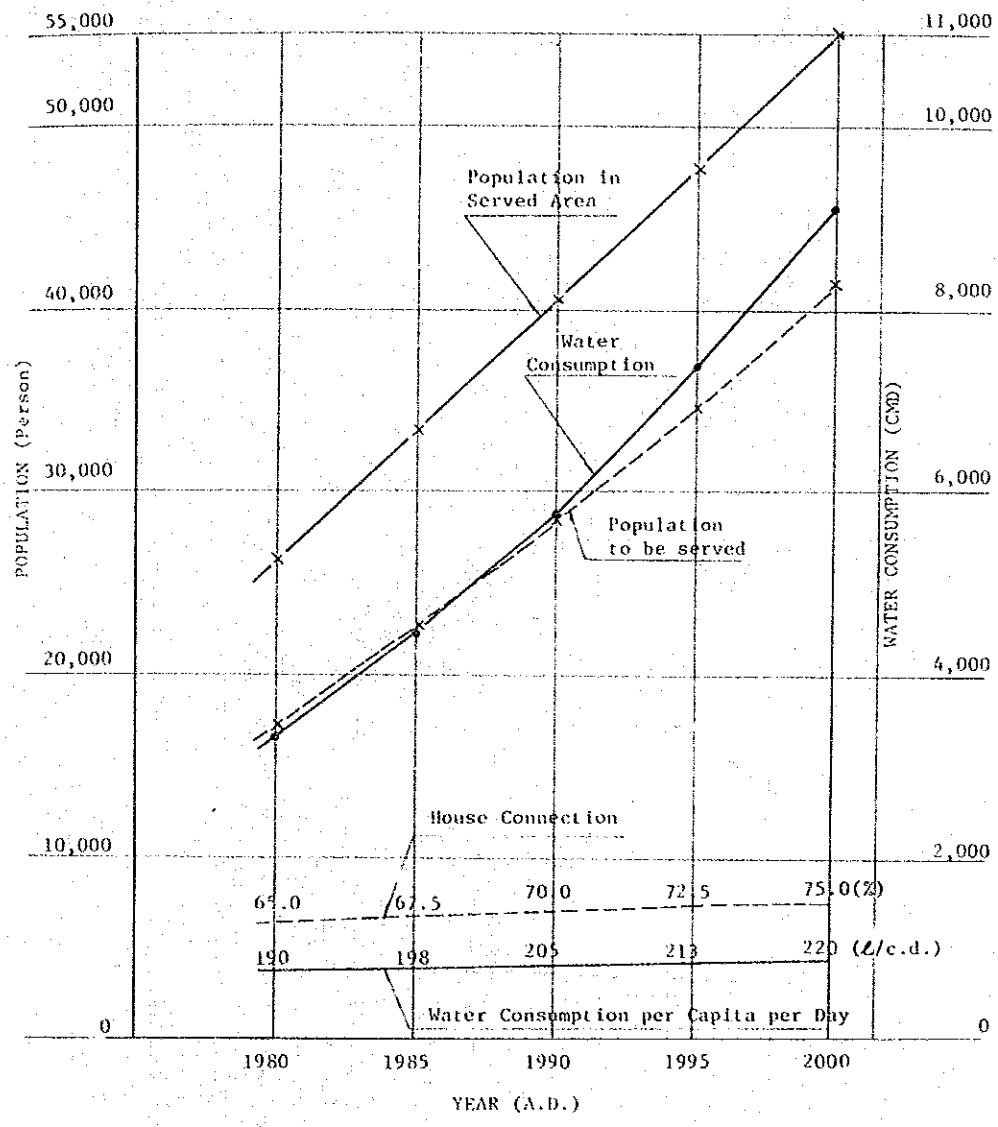


Table 3-25 BASIC PLAN - LAT KRABANG -

Item	Unit	1980	1985	1990	1995	2000
Population in Served Area	Person	26,500	33,600	40,700	47,900	55,000
House Connection	%	65.0	67.5	70.0	72.5	75.0
Population to be Served	Person	17,225	22,680	28,490	34,728	41,250
Daily Maximum Water Consumption per Head	ℓ/c.d	190	198	205	213	220
Daily Maximum Water Consumption	CMD	3,300	4,500	5,900	7,400	9,100

Fig. 3-25 BASIC PLAN - BANG PHLI -

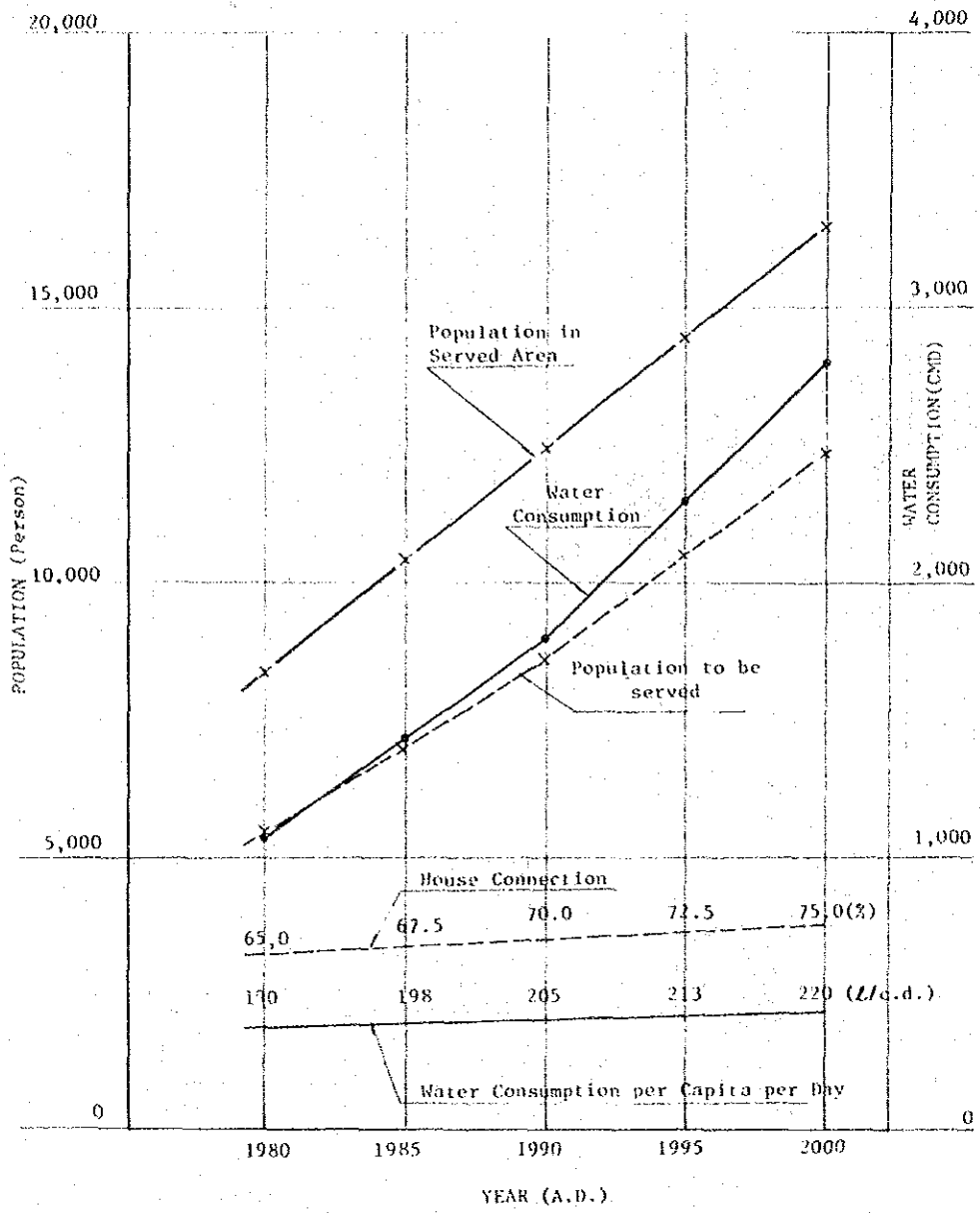


Table 3-26 BASIC PLAN - BANG PHLI -

Item	Unit	1980	1985	1990	1995	2000
Population in Served Area	Person	8,400	10,400	12,400	14,500	16,500
House Connection	%	65.0	67.5	70.0	72.5	75.0
Population to be Served	Person	5,460	7,020	8,680	10,513	12,375
Daily Maximum Water Consumption per Head	ℓ/c.d	190	198	205	213	220
Daily Maximum Water Consumption	CMD	1,100	1,400	1,800	2,300	2,800

Fig. 3-26 BASIC PLAN - BANG BO -

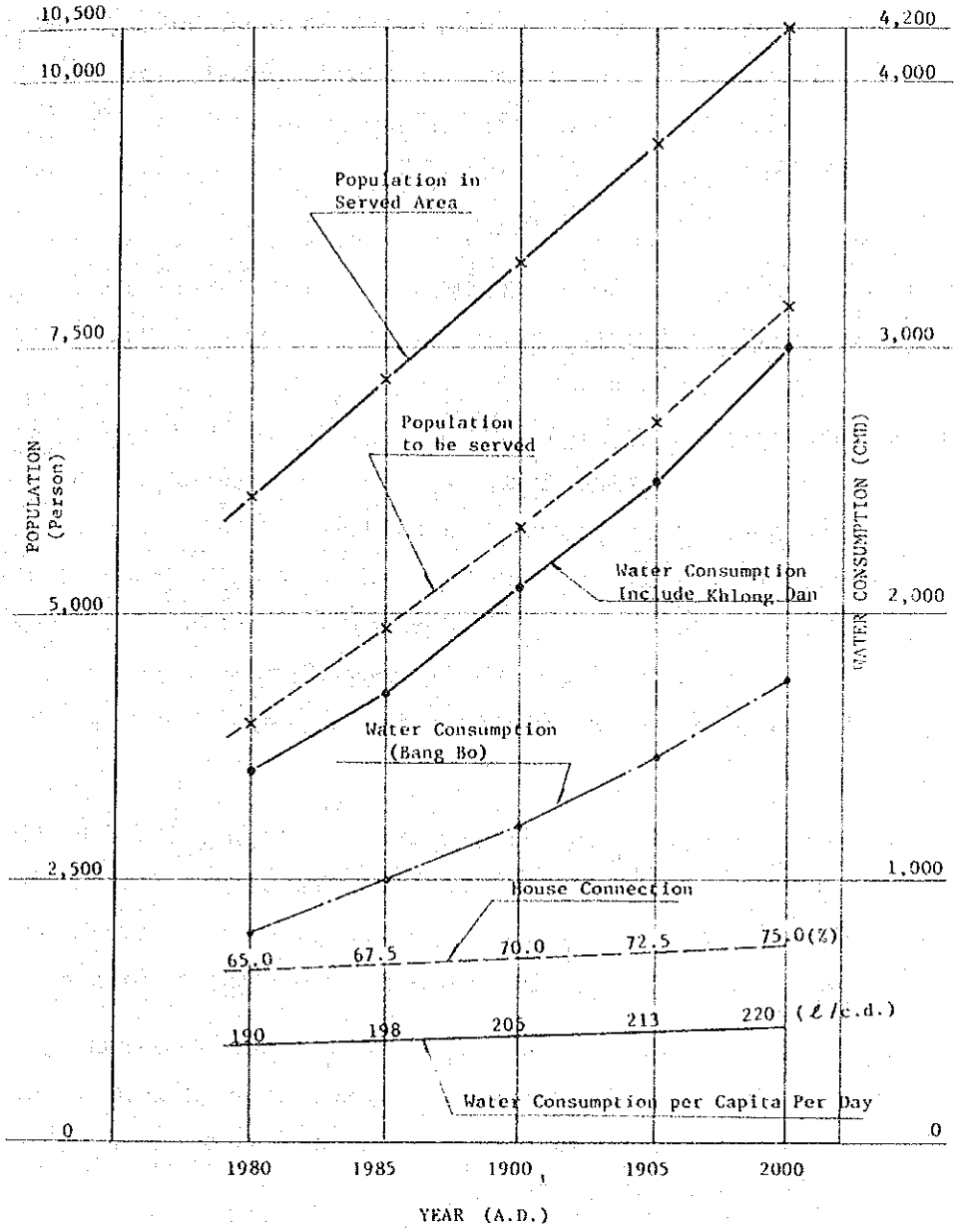


Table 3-27 BASIC PLAN - BANG BO -

Item	Unit	1980	1985	1990	1995	2000
Population in Served Area	Person	6,100	7,200	8,300	9,400	10,500
House Connection	%	65.0	67.5	70.0	72.5	75.0
Population to be Served	Person	3,965	4,860	5,810	6,815	7,875
Daily Maximum Water Consumption per Head	ℓ/c.d	190	198	205	213	220
Daily Maximum Water Consumption	CMD	800	1,000	1,200	1,450	1,750
Klong Dan	CMD	600	700	900	1,050	1,250
Total	CMD	1,400	1,700	2,100	2,500	3,000

3-4 Water Demand in Adjacent Development Area

Metropolitan Bangkok has a population of 4,560,000 and is one big cities of the world. The concentration of population in big cities is a worldwide phenomenon and Bangkok is not an exception to this trend.

When the concentration of population has reached a certain point, the development of an functional residential area is desired. In other words, as the public facilities like the traffic network are improved, population growth enters a stage where people build their houses in the suburban districts in preference to the congested center of the metropolis so that the metropolitan area further expands. In view of this trend in population growth,the adjacent development programs of Bangkok should naturally be incorporated into this study of the metropolitan water supply project. Accordingly a total of 11 adjacent development areas - consisting of 5 industrial complexes, 5 residential complexes and 1 airport - were included in the served area of this study.(See Fig. 2-1)

However, as these adjacent development areas has been decided. by the Industrial Estate Authority, National Housing Authority and Development of Commercial Aviation, no definite plan of water supply for each one of these adjacent development areas has been decided.

The annual water demand in the residential and industrial complexes was estimated in future by the respective agencies charged with the development program on the basis of the numbers of houses and buildings planned to be built.

Using the data made available by these agencies, the average family size was placed at 5 to 6 persons and the maximum daily household water consumption at 200 liters. As for the water demand in the adjacent industrial complexes, the water consumption per employee per placed at 50 liters and it was multiplied by the total number of employees. The value thus obtained was added to the estimation made by the Industrial Estate Authority.

On the other hand, the plan to build a new airport is at present only in the stage of feasibility study, hence, yet known is no more

than the approximate location and scale of the airport. The water demand in this new airport in 2000 was therefore estimated by using 4,200,000 passengers who will use Don Muan International Airport annually, and the average daily water demand per capita of 240 litters which is a water demand at Haneda International Airport, Japan, as of 1976. Further, the amount of water which would be used by airport facilities was added to the estimation, and a final estimation was arrived at as follows :

4,200,000 persons/day x 0.24 m^3/person/day + 620 CMD = 3,500 CMD.

The annual estimations of water demand in the adjacent development areas are shown in Tables 3-28, 3-29 and 3-30.

Table 3-28 WATER DEMAND FOR DEVELOPMENT PROGRAM AREA

(CMD)

Location			Year(AD) 1980	1985	1990	1995	2000
Right Bank	Bang Khun Thian	IN	-	-	-	-	-
		Ho	5,300	5,300	5,300	5,300	5,300
	Sub Total		5,300	5,300	5,300	5,300	5,300
Left Bank	Bang Chan	In	4,000	4,000	4,000	4,000	4,000
		Ho	1,100	1,100	1,100	1,100	1,100
	Lat Krabang	In	5,200	5,200	9,850	9,850	9,850
		Ho	2,730	13,330	26,000	38,000	38,000
	New Airport		1,500	2,000	2,500	3,000	3,000
	Bang Phli - Bang Bo	In	1,100	3,800	3,800	3,800	3,800
		Ho	4,000	12,000	20,000	20,000	20,000
	Bang Poo	In	10,400	10,400	20,700	31,200	41,500
		Ho	5,040	17,760	24,000	24,000	24,000
	Klong Dan	In	5,200	12,450	20,700	20,700	20,700
		Ho	-	-	-	-	-
	Sub Total		40,270	82,040	132,650	155,650	166,450
Total		In	25,900	35,850	59,050	69,550	79,850
		Ho	18,170	49,490	76,400	88,400	88,400
		Ne	1,500	2,000	2,500	3,000	3,500
Grand Total			45,570	87,340	137,950	160,950	171,750

In : Industrial Development Program

Ho : Housing Development Program

Table 3-29 WATER DEMAND FOR INDUSTRIAL DEVELOPMENT

(CMD)

Location \ Year(AD)		1980	1985	1990	1995	2000
Bang Chan	Fa	3,750	3,750	3,750	3,750	3,750
	Wo	250	250	250	250	250
Sub Total		4,000	4,000	4,000	4,000	4,000
Lat Krabang	Fa	5,000	5,000	9,500	9,500	9,500
	Wo	200	200	350	350	350
Sub Total		5,200	5,200	9,850	9,850	9,850
Bang Phli - Bang Bo	Fa	1,000	3,500	3,500	3,500	3,500
	Wo	100	300	300	300	300
Sub Total		1,100	3,800	3,800	3,800	3,800
Bang Poo	Fa	10,000	10,000	20,000	30,000	40,000
	Wo	400	400	700	1,200	1,500
Sub Total		10,400	10,400	20,700	31,200	41,500
Klong Dan	Fa	5,000	12,000	20,000	20,000	20,000
	Wo	200	450	700	700	700
Sub Total		5,200	12,450	20,700	20,700	20,700
Total	Fa	24,750	34,250	56,750	66,750	76,750
	Wo	1,150	1,600	2,300	2,800	3,100
Grand Total		25,900	35,850	59,050	69,550	79,850

Fa : Factory Use (CMD)

Wa : Worker Use (CMD)

Table 3-30 WATER DEMAND FOR NATIONAL HOUSING DEVELOPMENT

(CMD)

Location		Year(AD)	1980	1985	1990	1995	2000
Right Bank	Bang Khun Thian	Ho	5,302	5,302	5,302	5,302	5,302
		Po	26,510	26,510	26,510	26,510	26,510
		Wa	5,300	5,300	5,300	5,300	5,300
Left Bank	Bang Chan	Ho	916	916	916	916	916
		Po	5,496	5,496	5,496	5,496	5,496
		Wa	1,100	1,100	1,100	1,100	1,100
	Lat Krabang	Ho	2,728	13,333	26,000	38,000	38,000
		Po	13,640	66,665	130,000	190,000	190,000
		Wa	2,730	13,330	26,000	38,000	38,000
	Bang Phli — Bang Bo	Ho	4,000	12,000	20,000	20,000	20,000
		Po	20,000	60,000	100,000	100,000	100,000
		Wa	4,000	12,000	20,000	20,000	20,000
	Bang Poo	Ho	4,200	14,800	20,000	20,000	20,000
		Po	25,200	88,800	120,000	120,000	120,000
		Wa	5,040	17,760	24,000	24,000	24,000
Total		Ho	17,146	46,351	72,218	84,218	84,218
		Po	90,846	247,471	382,006	442,006	442,006
		Wa	18,170	49,490	76,400	88,400	88,400

Note : Ho : Number of Household
Po : Population to be Served (Person)
Wa : Water Demand (CMD)

3-5 Water Demand in Entire Area Covered by Separate System

The total water demand of the entire area to be covered by the separate system can be determined by adding the water demand in the adjacent development areas to the demand in 9 Amphoes.

The total water demand in the target year 2000 is placed at 249,550 CMD. Of that amount, 56,400 CMD is assumed to be consumed in the right bank area and 193,150 CMD in the left bank area.

Of the total water demand in the adjacent development areas, 88,400 CMD is assumed to be for household use and 83,350 CMD is assumed to arise from industrial and airport use.

On the basis of these water demand estimations, the water sources and a comprehensive water supply project will be planned for the right and left bank areas respectively.

The annual total water demand, curves of water demand, water demand ratio by purposes and water demand by districts are presented in Table 3-31, Figs. 3-27 and 3-28, and Table 3-32, respectively.

Table 3-31 TOTAL WATER DEMAND OF SEPARATE SYSTEM

(CMD)

Location		Year (AD) 1980	1982	1985	1990	1995	2000
Right Bank	Amphoes	11,800	14,800	19,300	27,000	37,000	51,100
	Development Program	5,300	5,300	5,300	5,300	5,300	5,300
	Sub Total	17,100	20,100	24,600	32,300	42,300	56,400
Left Bank	Amphoes	10,100	11,420	13,400	17,500	21,800	26,700
	Development Program	40,270	56,980	82,040	132,650	155,650	166,450
	Sub Total	50,370	68,400	95,440	150,150	177,450	193,150
Total	Amphoes	21,900	26,220	32,700	44,500	58,800	77,800
	Development Program	45,570	62,280	87,340	137,950	160,950	171,750
	Grand Total	67,470	88,500	120,040	182,450	219,750	249,550

Fig. 3-27 CURVES OF WATER DEMAND

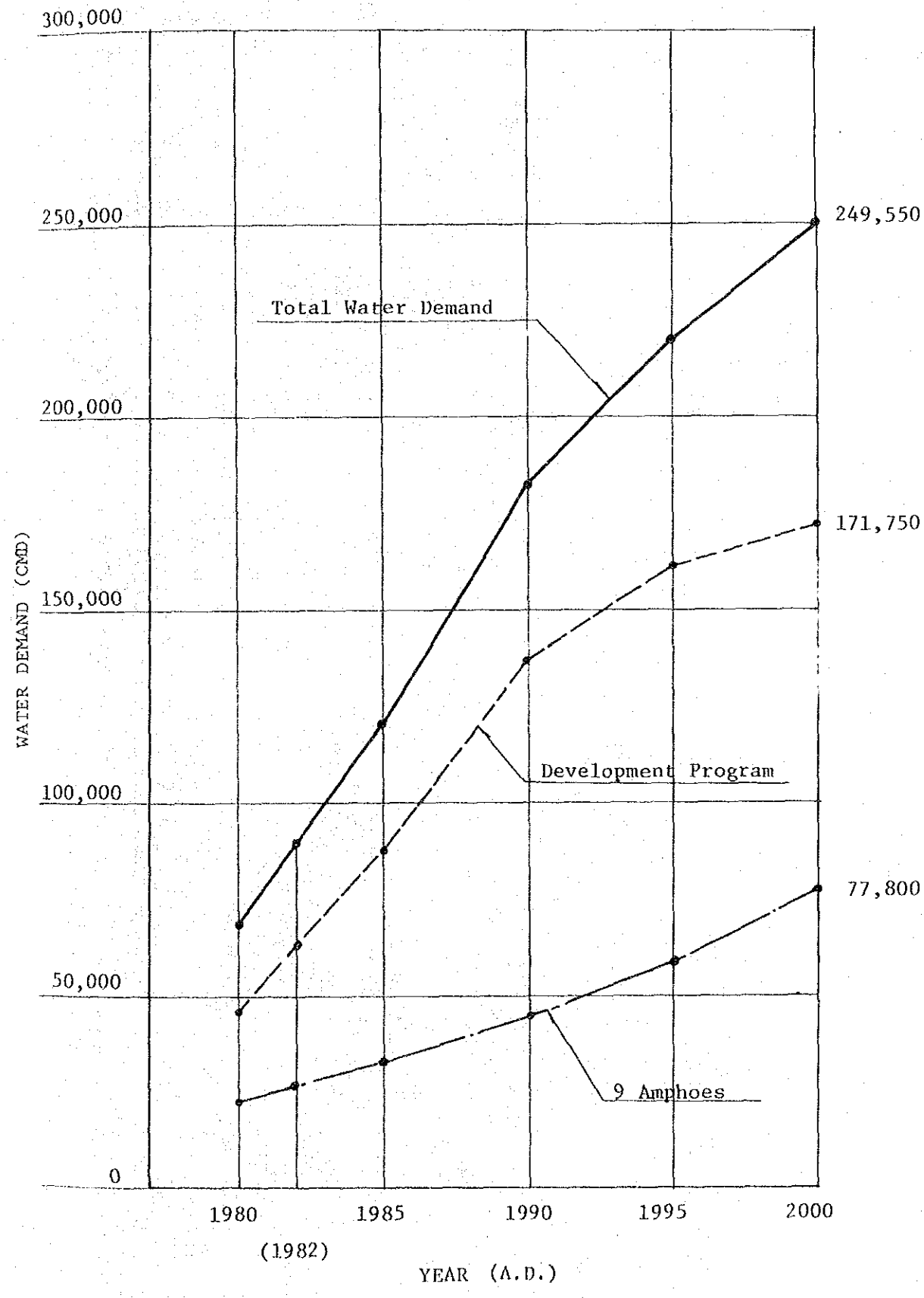


Table 3-32 WATER DEMAND OF SEPARATE SYSTEM

(CMD)

Location					Year (AD) 1980	1985	1990	1995	2000	Remarks
Right Bank	North 3 Districts	Amphoe	Sai Noi		500	700	900	1,200	1,500	
			Bang Bua Thong		2,000	2,700	3,400	4,300	5,200	
			Bang Yai		1,300	1,900	2,700	3,500	4,400	
		Sub Total			3,800	5,300	7,000	9,000	11,100	
	Nong Khaem Districts	Amphoe	Nong Khaem		8,000	14,000	20,000	28,000	40,000	
		Development Program	Bang Khun Thian	Ho	5,300	5,300	5,300	5,300	5,300	
		Sub Total			13,300	19,300	25,300	33,300	45,300	
	Total	Amphoe			11,800	19,300	27,000	37,000	51,100	
		Development Program			5,300	5,300	5,300	5,300	5,300	
		Total			17,100	24,600	32,300	42,300	56,400	
Left Bank	East 3 Districts	Amphoe	Nong Chok		1,400	2,000	2,800	3,600	4,500	
			Min Buri		2,900	3,800	4,900	6,000	7,300	
			Lat Krabang		3,300	4,500	5,900	7,400	9,100	
		Sub Total			7,600	10,300	13,600	17,000	20,900	
		Development Program	Bang Chan	In	4,000	4,000	4,000	4,000	4,000	
				Ho	1,100	1,100	1,100	1,100	1,100	
			Lat Krabang	In	5,200	5,200	9,850	9,850	9,850	
			Lat Krabang	Ho	2,730	13,330	26,000	38,000	38,000	
			New Airport		1,500	2,000	2,500	3,000	3,500	
		Sub Total			14,530	25,630	43,450	55,950	56,450	
	South 2 Districts	Amphoe	Bang Phli		1,100	1,400	1,800	2,300	2,800	
			Bang Bo		1,400	1,700	2,100	2,500	3,000	
		Sub Total			2,500	3,100	3,900	4,800	5,800	
		Development Program	Bang Phli - Bang Bo	In	1,100	3,800	3,800	3,800	3,800	
				Ho	4,000	12,000	20,000	20,000	20,000	
			Bang Poo	In	10,400	10,400	20,700	31,200	41,500	
				Ho	5,040	17,760	24,000	24,000	24,000	
			Klong Dan	In	5,200	12,450	20,700	20,700	20,700	
		Sub Total			25,740	56,410	89,200	99,700	110,000	
	Total	Amphoe			10,100	13,400	17,500	21,800	26,700	
		Development Program			40,270	82,040	132,650	155,650	166,450	
		Total			50,370	95,440	150,150	177,450	193,150	

In : Industrial Development

Ho : Housing Development

Fig. 3-28 WATER DEMAND RATIO (At 2000 AD)