

(4) Lifting volume for Each Well

The lifting volume will be determined by assuming the values for coefficient of transmissibility, coefficient of storage and the length of strainer. By the approximate estimation at this moment, the volume are obtained 980 CMD per one well for Sai Noi and Nong Chok, and 1,540 CMD per one well for Min Buri, Bang Phli, Bang Bo, Lat Krabang, Bang Bua Thong and Bang Yai areas.

These figures obtained above calculation are summarized as Table-4-2. The provisional location for planning well are shown Fig.-4-2.

Table-4-2

Location	Daily Demand CMD	Lifting Volume, CMD/well	No. of Wells	Recharge Area km ²	-do- per each well km ²
BANG PHLI	3,800	1,540	3	40	13.3
BANG BO	2,500	1,540	2	26.3	13.1
MIN BURI	7,300	1,540	5	76.8	15.4
NONG CHOK	4,500	980	5	47.3	9.5
LAT KRABANG	7,500	1,540	5	59.2	11.8
SAI NOI	1,500	980	2	15.8	7.9
BANG BUA THONG	5,200	1,540	4	41.1	10.3
BANG YAI	4,400	1,540	3	34.7	11.6

4.2 Surface Water

As being indicated in Fig.-4-3, it would be said that these Khlongs and Rivers seem to be feasible enough as water source which be able to supply water to the served area.

In general, the quantity and quality of such water must be most important factors as far as the water supply undertakings are concerned. In this respect, the Japanese Survey Team had collected many data in

Fig. 4-2

Location of Proposed Well

SCALE
1/200,000

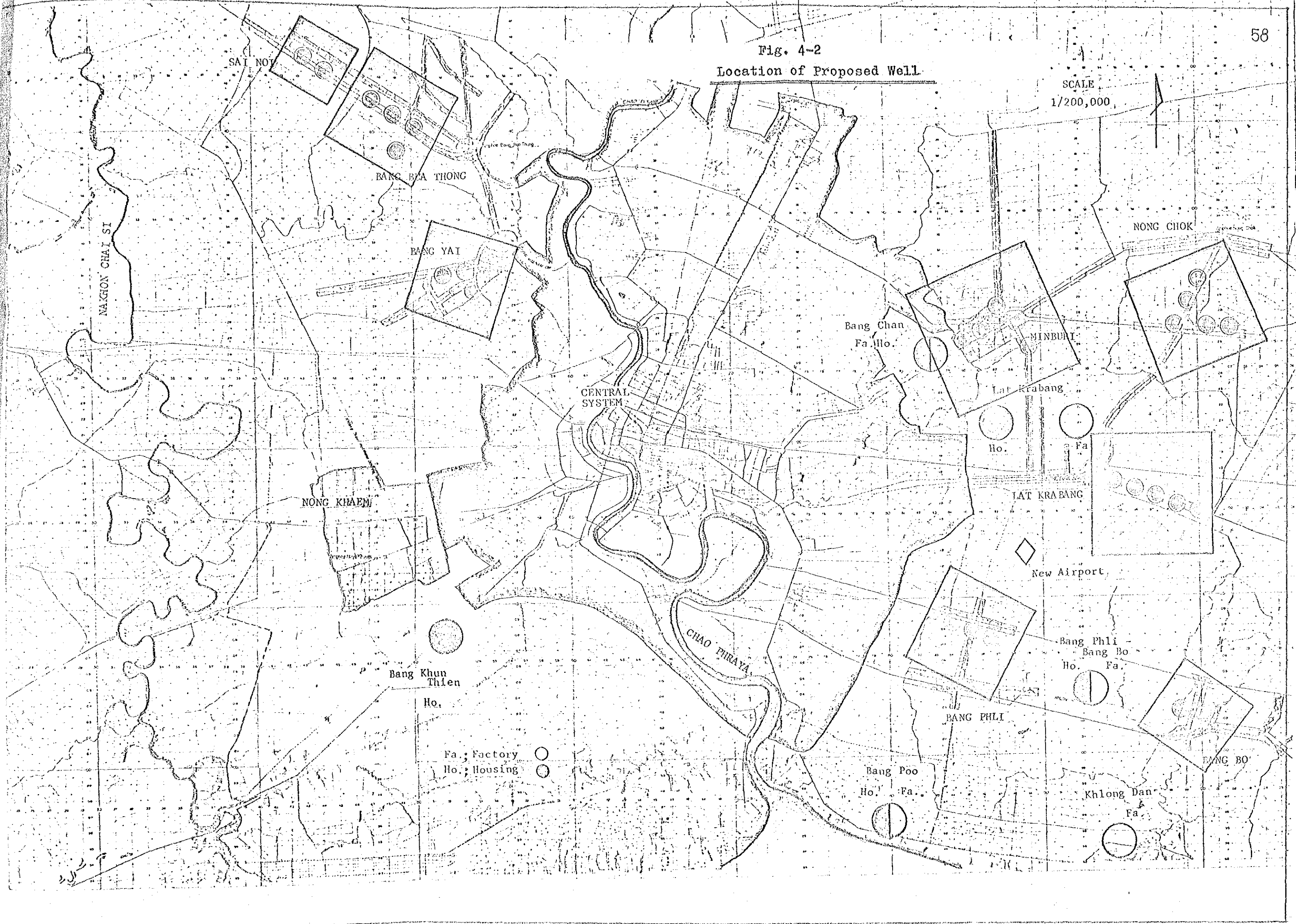
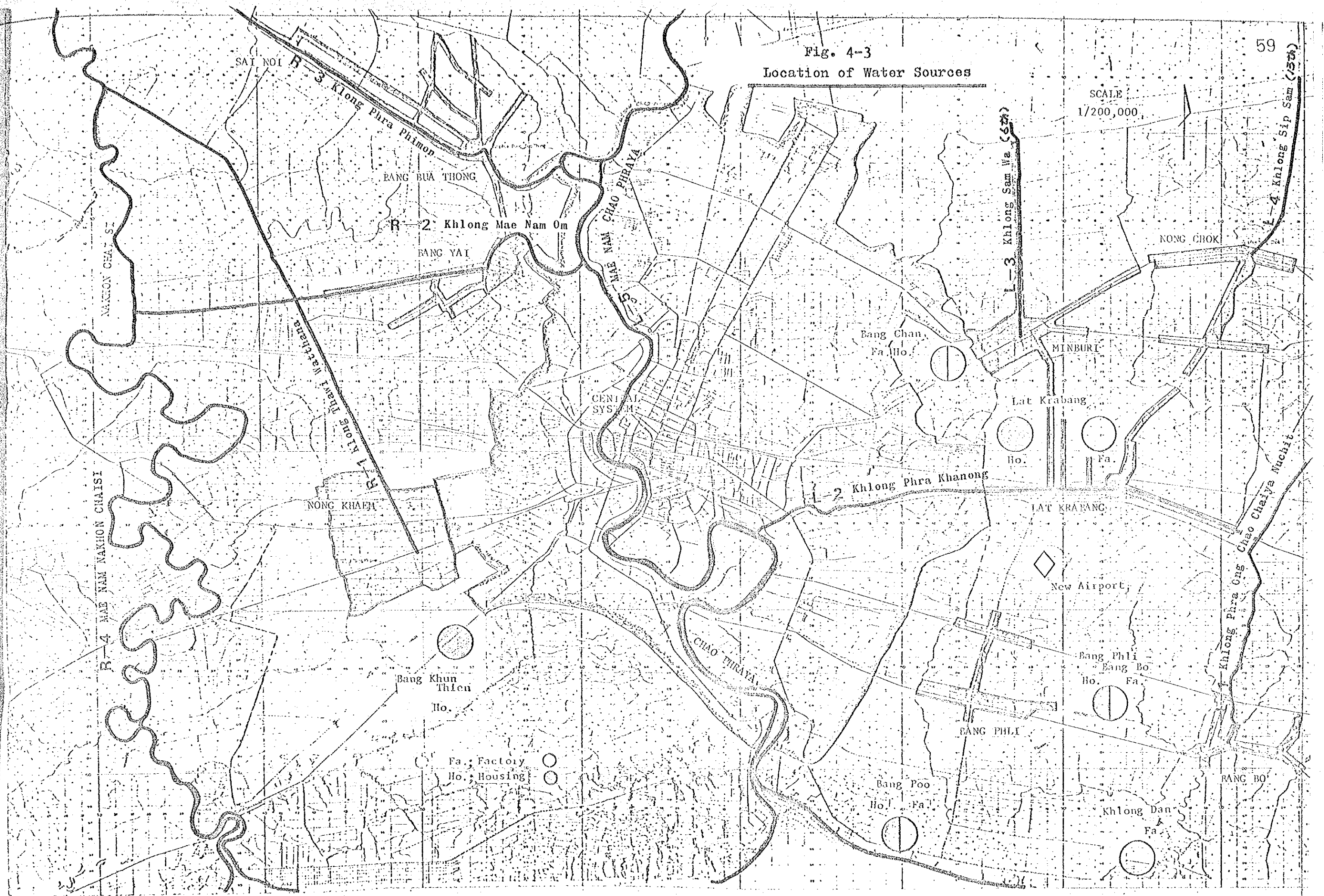


Fig. 4-3
Location of Water Sources

SCALE
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relating with a possibility of these sources to be used. The summary of data collected is as follows.

4-2-1 Right Bank of Chao Phraya River

1) Khlong Water

i) Khlong Thawi Watthana (R-1)

The Khlong Thawi Watthana had ever been recommended as a water source for the Amphoe Nong Khaem in the comparative studies carried out at 1973 by the former Japanese Survey Team. However, in that occasion, it had been mentioned that the domestic sewage and/or industrial wastes from dwellings and/or factories along the Khlong would be one of the reasons of water pollution in these surface water.

Judging from the data investigated by the Japanese Survey Team, it had been also suggested that the five (5) days BOD of Khlong will be an index of water pollution, in consequence of following data as a result of quantitative analysis.

Water Quality of Khlong Thawi Watthana

Point	Item	DO (ppm)	BOD-5 (ppm)	Remarks
	Amphoe Taling Chun	1.5	4.3	Near Railway Bridge
	Amphoe Phasi Charom	2.8	5.2	In front of Wat Saladaeng
	Amphoe Phasi Charoen	1.6	4.5	Near Petch Kasem Bridge

In general speaking, it is unlikely to take a surface water from Khlongs in which the five (5) days BOD is recorded more than four (4) ppm, which is considered to indicate the maximum tolerant level of pollution.

In addition to the fact above-mentioned, the previous value of five (5) days BOD was only 1.6 ppm in 1973, which means that

the pollution has increased rapidly at rate of 0.8 ppm per year, in the result of three (3) times as much as previous value. On the other hand, as will be mentioned in Chapter 7 Ref. No. 9 from the viewpoint of quantity of the Khlong, some restriction for water consumption must be made to correspond with the water demand for Nong Khaem Area, because of shortage in dry season.

As being studied above, it is obliged to deem that the Khlong Thawi Watthana is not suitable for the water sources, taking water quality and quantity into consideration.

ii) Khlong Mae Nam Om (R-2)

It is well-known that the Khlong Mae Nam Om is one of the tributaries of Chao Phraya River. Thus, it is seemed that the capacity of this Khlong is good enough for water source. Furthermore, there is no water gate and other facilities to control the flow of tributary, so that the quality of its water must be nearly same as that of Chao Phraya River.

According to the description concerning to serious pollution in the water of Khlong Thawi Watthana, the Khlong Mae Nam Om will be considered available for a water source of right bank of Separate System, if the Authority would agree to give up using the Khlong Thawi Watthana as a water source. Meantime, water pollution analysis shall also be involved in the water quality survey of Chao Phraya River in any case.

iii) Khlong Phra Phimon (R-3)

The Khlong Phra Phimon might be considered as a water source for Sai Noi District where is located far away from other sanitary districts, because this Khlong is now flowing through the center of Sai Noi as being shown in Fig. 4-3. However, unfortunately, water pollution of this Khlong is also remarkable and quantity of water is not enough. Therefore, the Khlong Phra Phimon shall be abandoned from the selection of water source.

2) River

i) Nakhon Chai Si River (R-4)

Judging from additional investigation for surface water, the River Nakhon Chai Si will be situated as water source for right bank of Chao Phraya River, although the Khlong Mae Nam Om is seemed to be a feasible water source, because of adjacent location to severral Amphoe such as Sai Noi and Bang Bua Thong..

In respect of total demand of right bank as 56,400 CMD (0.65 cu.m./sec.) in target year of 2000 AD, it is clear that the flow of Nakhon Chai Si River is good enough to cover such demand, because it has been informed from Royal Irrigation Department that total discharge of the River is approximately 50 cu.m./sec. in dry season, among which 30 cu.m./sec. shall be kept to prevent an intrusion of sea water into upstream, and consequently 20 cu.m./sec. would be available to be used for water supply system.

If it is possible to compare two figures above mentioned, it seems to be good balance because 20 cu.m./sec. is obviously enough to cover the water demand of 0.65 cu.m./sec. On the contrary, the intrusion of sea water will bring rather difficult problem in standpoint of water quality, because the gradient of Nakhon Chai Si River is quite flat. There are quite few data about chloride content in the water of Nakhon Chai Si River, however, the water analysis of chloride content shall be carried out in order to confirm the data in past. Consequently, it is recommended to take necessary steps to confirm the chloride content in the water by additional survey.

4-2-2 Left Bank of Chao Phraya River

1) Khlong Water

i) Khlong Phra Ong Chao Chaiya Nuchit (L-1)

Being indicated in Fig. 4-3, the Khlong Phra Ong Chao Chaiya Nuchit looks like a reasonable source to serve water to Amphoe Bang Bo

and Bang Phli, taking its situation into consideration. Judging from appearance of the Khlong water, it is clear to meet with standard of drinking water.

At present, amount of 4,800 CMD water has been taken from this khlong as a water source of Chachoeng Sao Water Works Undertaking which belongs to Public Works Department, and another 4,800 CMD water is now planning to supply to a extension work of the undertaking in near future.

In addition to the fact abovementioned, it has been also planned that amount of 5,000 CMD water will be taken from this Khlong to Bang Prakong Water Works Undertaking which also belongs to PWD.

From these standpoints, it seems to be somewhat difficult to desingate the khlong water as a source for the Amphoe such as Bang Bo, Bang Phli, Khlong Dan and Bang Poo.

ii) Khlong Phra Khanong (L-2)

Under previous survey made in 1973, the Khlong Phra Khanong had been recommended as a water source to Amphoe Lat Krabang, subject to an periodic elimination of water pollution. As the fact, five (5) days BOD test had shown the value of 2 ppm which reaches to a saturation of pollution. To compare with the water in Khlong Thawi Watthana which had shown 1.6 ppm, this Khlong had been somewhat doubtful to be a water source.

Apart from the previous study made in 1973, additional survey was done in this field study. However, unfortunately, the Khlong and its surroundings have not been improved during past four (4) year in term of water quality preservation.

iii) Khlong 6th (L-3) & Khlong 13th (L-4)

These two Khlongs are situated in the Amphoe Town of Min Buri and Nong Chok. Since these two Khlongs have a vast water-shed area surrounded by KHUAYAI mountain range situating at northern part of

Thailand, the discharge of these two Khlongs are recorded that the discharge of Khlong 13th is 20 cu.m./sec. in flood season and 5 cu.m./sec. even in dry season.

On the other hand, the total water demand in left bank of Chao Phraya River is 193,000 CMD in the target year of AD 2000, in comparison with the quantity of Khlong 13th as 432,000 CMD (5 cu.m./sec as mentioned before). Therefore, it is possible to designate Khlong 13th as a water source for all of planned sanitary district in left bank, taking the quantity of this Khlong into consideration.

2) Chao Phraya River (L-5)

Chao Phraya River will have a significant possibility as the water source for the Separate System when wells and khlong water become useless.

According to recent investigation by RID for the discharge of Chao Phraya River, total amount of discharge is 85 cu.m./sec. at the lower stream of this river, among which 60 cu.m./sec. is to be used for intrusion prevention from sea water and another 25 cu.m./sec. (2,160,000 CMD) is available for use of Central System.

On the other hand, future raw water demand of Central System is as followings.

Judging from the Table 4-3, it will become necessary to undertake some special program for water reconnaissance throughout Thailand in order to supply enough and safe drinking water to Central System as soon as possible.

4-3 Proposed Reservoir of Central System

Study of water sources for Separate System has been concentrated only to the possible wells and surface waters in this section. On the other hand, it is necessary to remind that there is another source which seems to be feasible to transmit a clear water from Central System to the Separate System.

The Table 4-4 shows a comparison study between water demand of Central System and Separate System at AD 1985 and AD 2000.

According to this Table 4-4, water demand of Separate System at AD 2000 occupies only five (5) percent of total demand for not only Central System and also Separate System.

Therefore, it would be possible to send clear water from Central System to Separate System, subject to clarify other remaining problems.

4-4 Water Sampling

Sampling for water quality analysis has been conducted as follows;

- 1) Analysis for intrusion of Chao Phraya River and Nakhon Chai Si River,
- 2) Analysis for water quality of khlong water,
- 3) Analysis for water quality of well water

Among these as mentioned in 4-2, Chao Phraya River and Nakhon Chai Si River seems to be no problem about water quality except term of salinity.

On the other hand, some of khlong water shall be carefully checked in term of five (5) days BOD in addition to the physical examination as being mentioned 4-2. For reference, numbers of sampling point are indicated below.

Location	Item	Number
Khlong	Ordinary Test Including Jar Test & D.O. , BOD-5	6
	Ordinary Test Including Jar Test	1
	Only D.O. & BOD-5	1
River	Only Chlorine	12
Well	Ordinary Test	8
Total		28

Table-4-3: Demand Estimates of Raw Water for Water Supply in Bangkok Metropolitan Areas

Year	Raw Water Required			
	Surface Water cu.m./day	Ground Water cu.m./day	Total cu.m./day	Ground Water as Percentage of cu.m./day
1975	1,000,000	350,000	1,350,000	25.92
1977	1,000,000	438,000	1,438,000	30.45
1978	1,800,000	580,000	2,380,000	29.36
1980	2,800,000	330,000	3,313,000	10.54
1985	3,600,000	160,000	3,760,000	4.25
1990	4,800,000	-	4,800,000	-
1995	6,000,000	-	6,000,000	-
2000	6,000,000	-	6,000,000	-

Table -4-4: Water Demand of Central System and Separate System

(unit: 1,000 CMD)

Year	Right Bank		Left Bank		Total		Ground Total	Separate System (% of Total Demand)
	Central System	Separate System	Central System	Separate System	Central System	Separate System		
1985	1,462	25	1,227	100	1,689	125	1,814	7.0
2000	1,064	60	3,558	190	4,622	250	4,872	5.0

* Excluding capacity of existing treatment plant & well

Result of Water Quality Analysis

1. Khlong

Chemical Analysis	R-1-1	R-1-2	R-1-3	R-2	L-1	L-2	L-3	L-4
Color	nil	nil	nil	nil	nil		nil	nil
Odor	"	"	"	"	"		"	"
Turbidity	125	170	80	22.0	89		73	75
pH	7.10	7.22	7.46	7.4	7.3		7.2	7.65
Methyl Orange Alkalinity	110	112	136	92	134		82	88
Phenolphthalein Alkalinity	nil	nil	nil	nil	nil		nil	nil
Total Solids	574	954	436	152	642		303	415
Dissolved Solids	206	230	250	100	310		120	90
Suspended Solids (by M.F.)	-	-	-	-	262		154	295
Total Hardness as Calcium Carbonate	140	152	144	94	152		106	88
Carbonate Hardness	110	112	136	92	134		82	88
Non-Carbonate Hardness	30	40	8	2	18		24	nil
Chloride as Chlorine	25	40	66	8	92		10	8
Sulphate as Sodium Sulphate	42.6	-	-	6.4	59.6		52.5	22.7
Oxygen Consumed 37°C. 3 hours	5.782	7.036	6.554	1.620	6.112		2.222	0.889
Ammonia free as Nitrogen	0.700	0.564	1.056	0.336	-		0.496	0.404
Ammonia-albuminoid as Nitrogen	1.092	1.348	1.124	0.408	-		0.604	0.804
Total Organic N. as Nitrogen	-	-	-	-	-		-	-
Nitrate as Nitrogen	0.625	0.385	0.025	0.250	0.175		0.115	nil
Nitrite as Nitrogen	0.0530	0.0374	0.0194	0.002	0.0218		0.0176	0.0046
Calcium	-	-	-	-	-		-	-
O-Phosphate	0.14	0.07	0.23	0.13	-		-	-
Iron	4.0	7.8	2.0	0.52	3.7		1.63	1.77
Fluoride as Fluorine	-	-	-	0.39	-		-	-
Manganese	0.207	0.450	0.070	nil	0.263		nil	nil
Magnesium	-	-	-	-	-		-	-
Free Carbon Dioxide	11	14	14	6.0	-		-	-
D.O.	1.5	2.8	1.6	4.7	0.5	0.1	2.6	-
B.O.D.	4.3	5.2	4.5	1.3	2.2	4.2	0.8	-
Bacteria 37°C-24hrs. (Number/ml)	11,000	18,000	35,000	16,500	18,000		24,000	13,000
Coliform bacteria (")	115,000	135,000	44,000	23,000	47,000		261,000	162,000
Faecal coliform (Number/100 ml)	55,000	60,000	81,000	5,000	2,000		66,000	14,000

Note: R-1-1, Khlong Thawee Wattana
R-1-2, " " "
R-1-3, " " "
R-2, Khlong Mae Nam Om
L-1, Khlong Phra Ong Chaiya Nuchit
L-2, Khlong Phra Khanong
L-3, Khlong Sam Wa
L-4, Khlong Sip Sam

Result of Water Quality Analysis

2. River

(ppm)

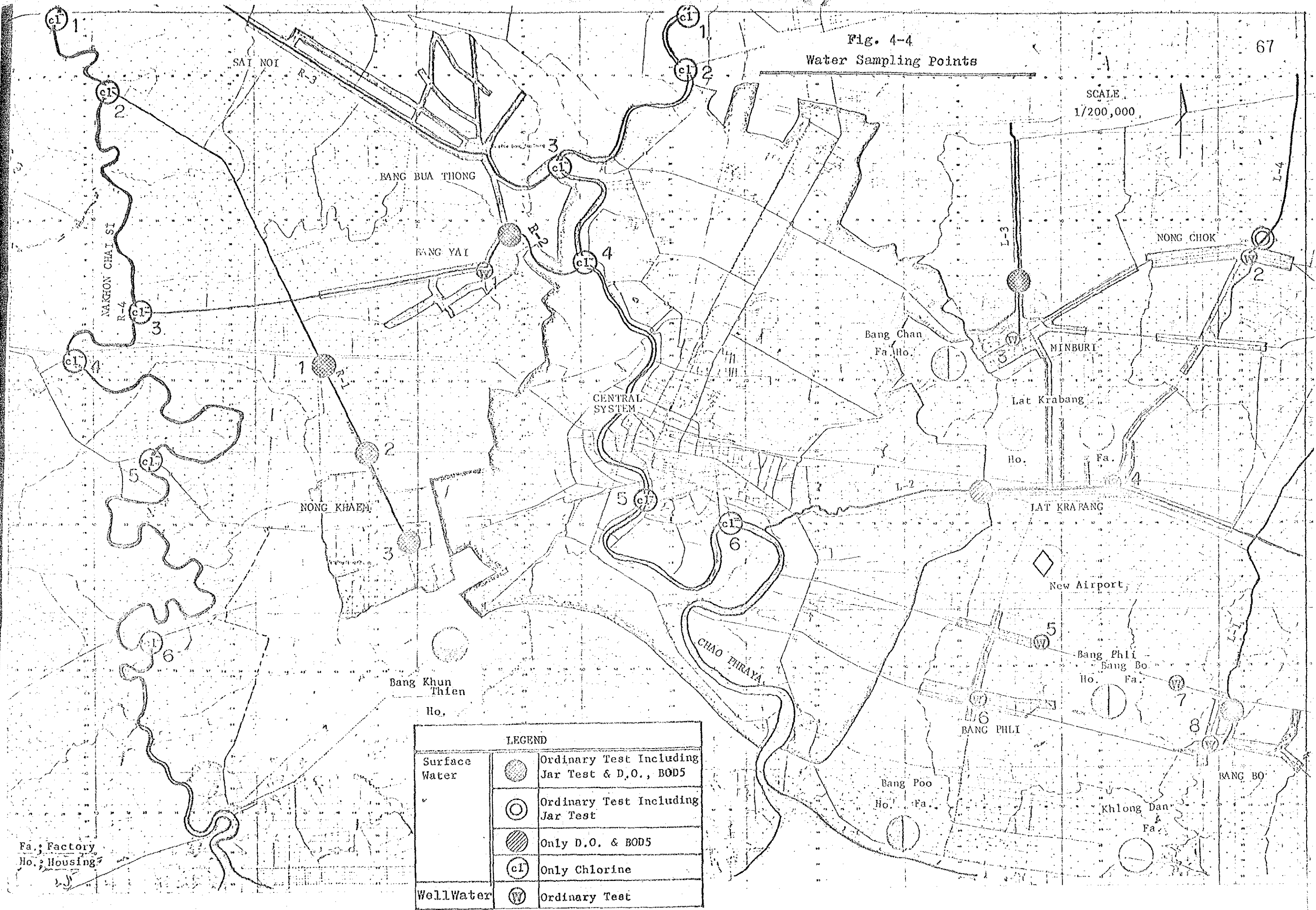
	Chao Phraya River			Nakhon Chai Si River		
	Surface	Middle	Bottom	Surface	Middle	Bottom
1	11.0		10.0	10.0	9.0	8.0
2	10.0		11.0	13.0	11.0	11.0
3	11.0		10.0	13.0	15.0	14.0
4	13.0		12.0	14.0	17.0	16.0
5	30.0		45.0	19.0	18.0	17.0
6	2,750.0		3,850.0	144.0	-	-

3. Well Water

Item	Place	W-1	W-2	W-3	W-4	W-5	W-6	W-7	W-8
		Bang Yai	Nong Chok	Min Buri	Lat Krabang	Bang Phli 1	Bang Phli 2	Bang Bo 1	Bang Bo 2
Color		nil	nil	nil	nil	nil	nil	nil	nil
Odor		"	"	"	"	"	"	"	"
Turbidity		3.6	0.5	2.3	1.2	14.0	2.8	1.3	3.4
pH		7.1	7.98	7.55	7.5	7.6	7.5	7.92	7.7
Methyl Orange Alkalinity		256	430	368	386	292	340	328	282
Phenolphthalein Alkalinity		nil	14	8	4	nil	nil	8	nil
Total Solids		364	926	500	534	507	654	567	740
Dissolved Solids		330	730	390	400	375	510	430	595
Suspended Solids		-	-	-	-	-	-	-	-
Total Hardness as Calcium Carbonate		166	120	96	86	136	172	76	148
Carbonate Hardness		166	120	96	86	136	172	76	148
Non-Carbonate Hardness		nil	nil	nil	nil	nil	nil	nil	nil
Chloride as Chlorine		40	126	18	13	43	118	48	166
Sulphate as Sodium Sulphate		9.7	73.8	58.2	48.2	61.1	75	12.8	110
Oxygen Consumed 37°C. 3 hours		-	-	-	-	-	-	-	-
Ammonia-free as Nitrogen		-	-	-	-	-	-	-	-
Ammonia-albuminoid as Nitrogen		-	-	-	-	-	-	-	-
Total Organic N. as Nitrogen		-	-	-	-	-	-	-	-
Nitrate as Nitrogen		-	nil	nil	nil	nil	nil	nil	trace
Nitrite as Nitrogen		-	trace	trace	trace	trace	0.0026	trace	0.0036
Calcium		-	-	-	-	-	-	-	-
O-Phosphate		0.03	-	-	-	-	-	-	-
Iron		0.40	nil	nil	nil	2.4	nil	nil	nil
Fluoride as Fluorine		0.39	-	-	-	-	-	-	-
Manganese		0.31	trace	trace	trace	trace	nil	nil	nil
Magnesium		-	-	-	-	-	-	-	-
Free Carbon Dioxide		56.0	28.0	34.0	36.0	28.0	22.0	16.0	42.0
MPN per 100 ml		0	0	0	0	0	38	0	38
24hr. Total Plate Count at 37°C		0	0	0	0	2	49	14	11

Fig. 4-4
Water Sampling Points

SCALE
1/200,000



LEGEND	
Surface Water	● Ordinary Test Including Jar Test & D.O., BOD5
	⊙ Ordinary Test Including Jar Test
	▨ Only D.O. & BOD5
	(cl) Only Chlorine
Well Water	⊕ Ordinary Test

Fa. : Factory
Ho. : Housing

5. Outline of Comparative Study

To cover the water demand for separate system, several comparative plans shall be provided including comprehensive water supply system. Judging from various studies, following four alternatives shall be discussed as water source for Separate System.

- 1) Well with suitable capacity to meet with water demand of each Amphoe,
- 2) Khlong with good quality and enough quantity,
- 3) Chao Phraya River and Nakorn Chai Si River,
- 4) Water supply from Central System,

Considering water supply system for each Amphoe with water sources mentioned above, comparative plans will be studied five (5) cases for the right bank and four (4) cases for the left bank. The combination of water supply area are shown on Table 5-1, 5-2 and sketches for each cases are outlined on Fig. 5-1 through Fig. 5-9.

Table 3-1

Comparative Plans for The Right Bank of Chao Phraya River

	Water Source	Water Demand (CMD)	Surved Area
Case 1 (R)	Central System	56,400	Amphoe: Sai Noi, Bang Bua Thong, Bang Yai Nong Khaem Additional Area: Bang Khun Thien
Case 2 (R)	Well	11,100	Amphoe: Sai Noi, Bang Bua Thong, Bang Yai
	Central System	45,300	Amphoe: Nong Khaem Additional Area: Bang Khun Thien
Case 3 (R)	Well	11,100	Amphoe: Sai Noi, Bang Bua Thong, Bang Yai
	Surface (Nakhon Chai Si)	45,300	Amphoe: Nong Khaem Additional Area: Bang Khun Thien
Case 4 (R)	Khlong (Mae Nam Om)	11,100	Amphoe: Sai Noi, Bang Bua Thong, Bang Yai
	Central System	45,300	Amphoe: Nong Khaem Additional Area: Bang Khun Thien
Case 5 (R)	Khlong (Mae Nam Om)	56,400	Amphoe: Sai Noi, Bang Bua Thong, Bang Yai, Nong Khaem Additional Area: Bang Khun Thien

Table 5-2

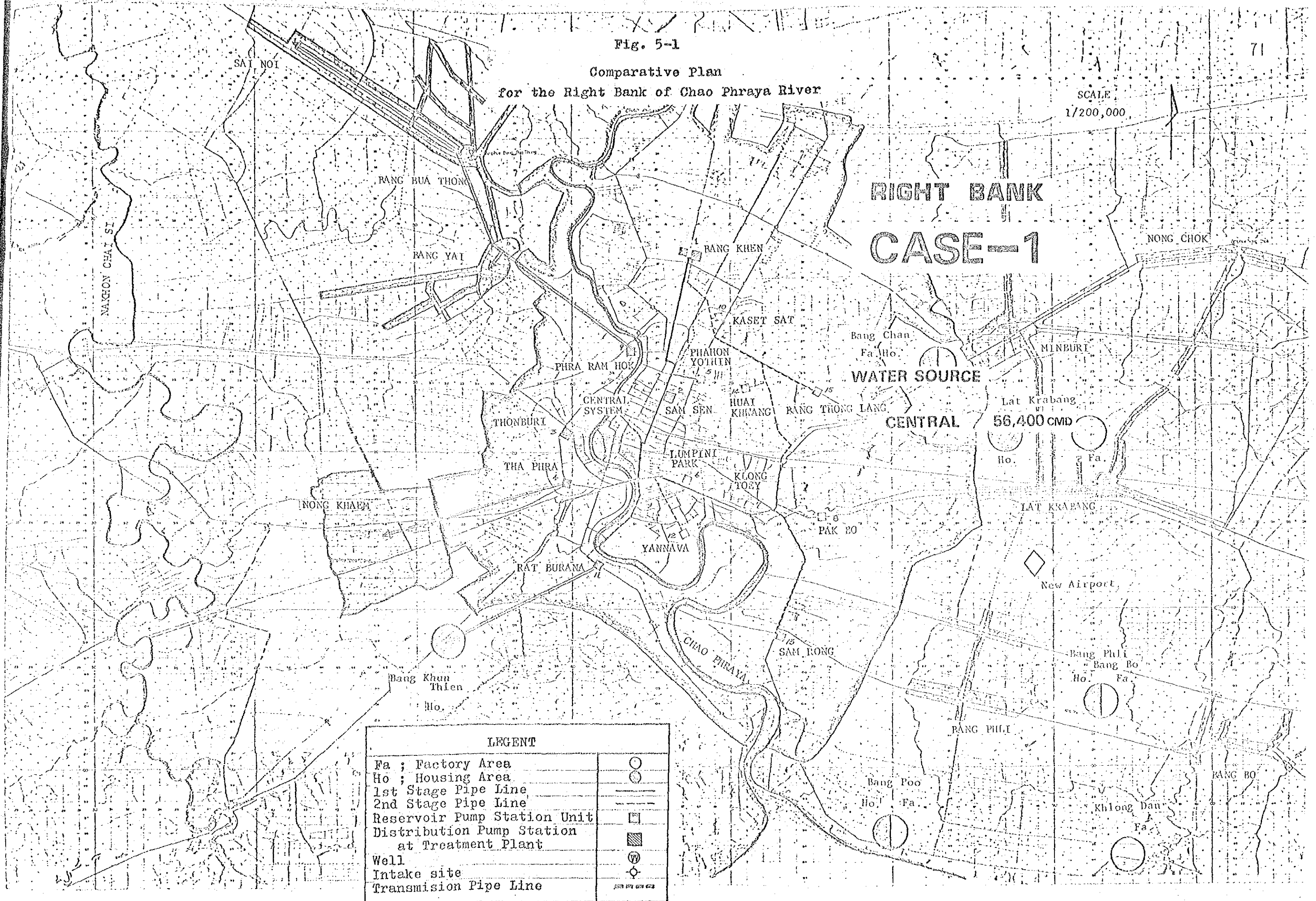
Comparative Plans for The Left Bank of Chao Phraya River

	Water Source	Water Demand (CMD)	Surved Area
Case 1 (L)	Well	26,650	Amphoe: Min Buri, Nong Chok, Lat Krabang, Bang Phli, Bang Bo
	Central System	166,450	Additional Area: Bang Chan, Lat Krabang, New Airport, Bang Phli, Bang Bo, Khlong Dan, Bang Poo
Case 2 (L)	Well	26,650	Amphoe: same Case 1 (L)
	Khlong (Khlong 6th, 13th)	166,450	Additional Area: same Case 1 (L)
Case 3 (L)	Central System	193,100	Amphoe: Min Buri, Nong Chok, Lat Krabang, Bang Phli, Bang Bo
	Khlong (Khlong 6th, 13th)	193,100	Additional Area: Bang Chan, Lat Krabang, New Airport, Bang Phli, Bang Bo, Khlong Dan, Bang Poo
Case 4 (L)			Amphoe: same Case 3 (L)
			Additional Area: same Case 3 (L)

Fig. 5-1

Comparative Plan
for the Right Bank of Chao Phraya River

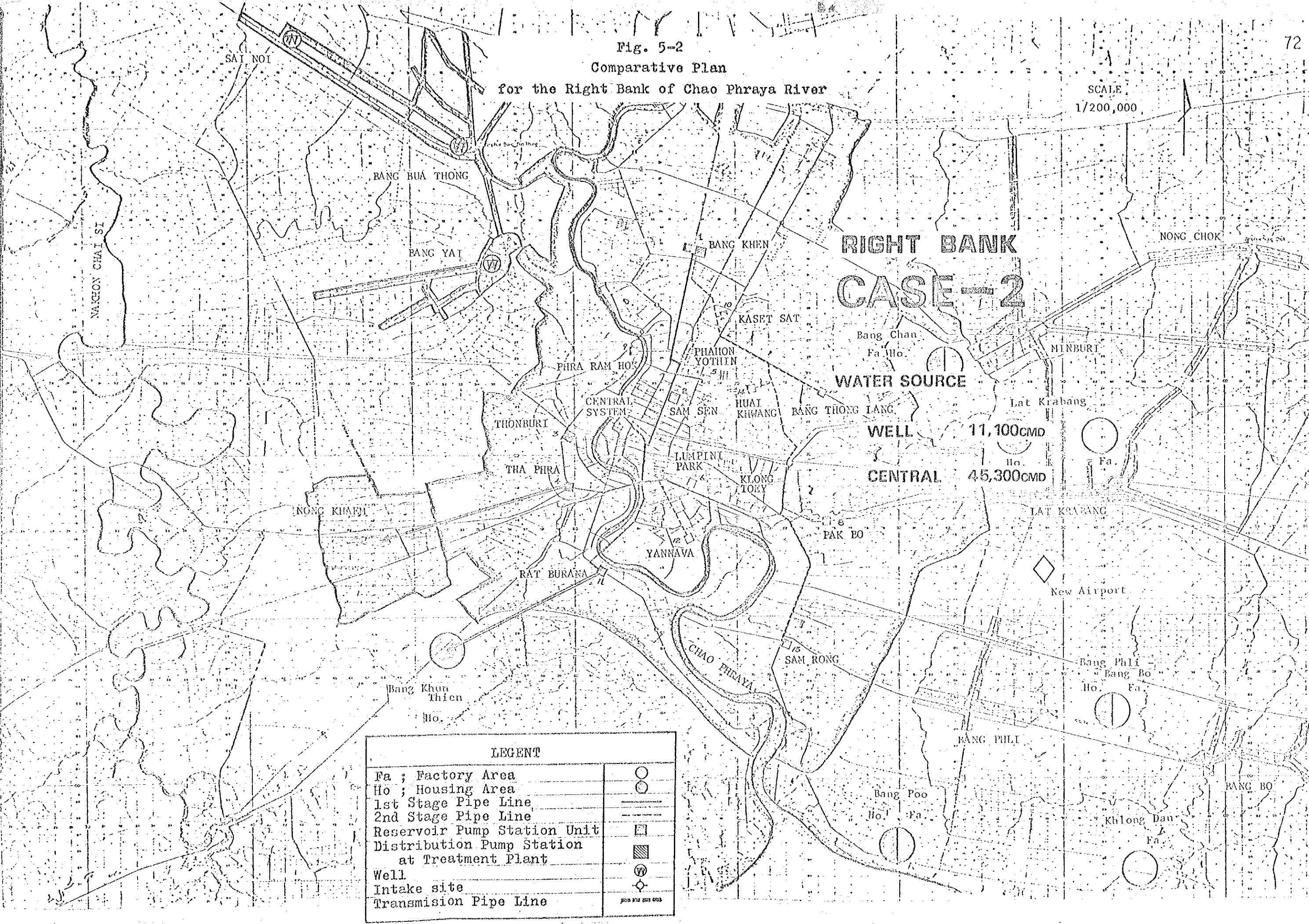
SCALE
1/200,000



LEGENT	
Fa ; Factory Area	○
Ho ; Housing Area	○
1st Stage Pipe Line	—
2nd Stage Pipe Line	—
Reservoir Pump Station Unit	□
Distribution Pump Station at Treatment Plant	▨
Well	⊙
Intake site	◇
Transmission Pipe Line	—

Fig. 5-2
Comparative Plan
for the Right Bank of Chao Phraya River

SCALE
1/200,000



RIGHT BANK CASE - 2

WATER SOURCE

WELL 11,100CMD
Ho. Fa.

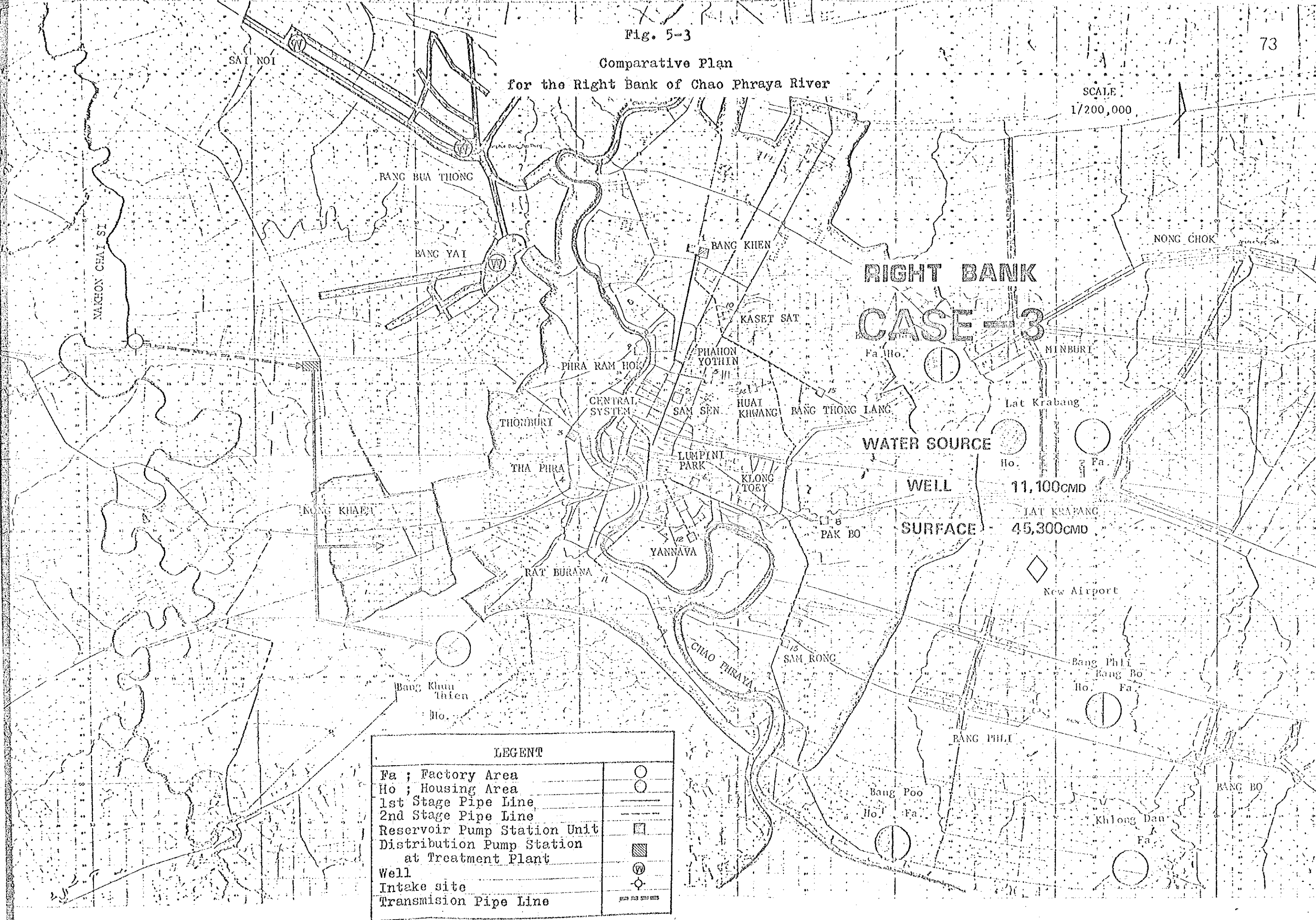
CENTRAL 45,300CMD
Ho. Fa.

LEGENT	
Fa ; Factory Area	○
Ho ; Housing Area	○
1st Stage Pipe Line	—
2nd Stage Pipe Line	—
Reservoir Pump Station Unit	□
Distribution Pump Station at Treatment Plant	▨
Well	⊙
Intake site	◇
Transmission Pipe Line	—

Fig. 5-3

Comparative Plan
for the Right Bank of Chao Phraya River

SCALE
1/200,000



RIGHT BANK
CASE-3

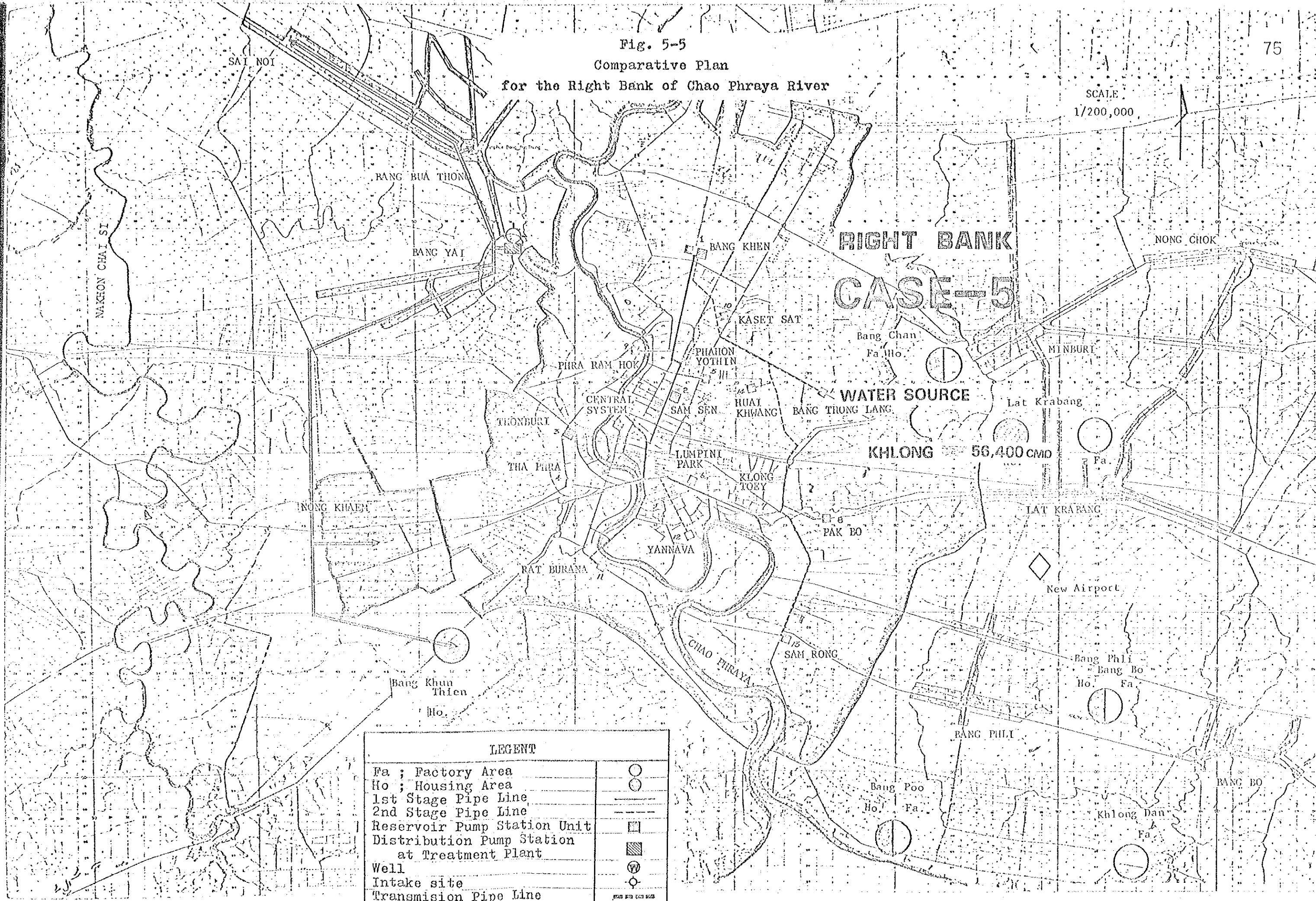
WATER SOURCE
WELL 11,100CMD
SURFACE 45,300CMD

LEGENT	
Fa ; Factory Area	○
Ho ; Housing Area	○
1st Stage Pipe Line	—
2nd Stage Pipe Line	—
Reservoir Pump Station Unit	□
Distribution Pump Station at Treatment Plant	▨
Well	⊙
Intake site	◇
Transmission Pipe Line	—

Fig. 5-5

Comparative Plan
for the Right Bank of Chao Phraya River

SCALE
1/200,000



LEGENT	
Fa ; Factory Area	○
Ho ; Housing Area	○
1st Stage Pipe Line	—
2nd Stage Pipe Line	—
Reservoir Pump Station Unit	□
Distribution Pump Station at Treatment Plant	▣
Well	⊙
Intake site	⊙
Transmission Pipe Line	—

Fig. 5-6

Comparative Plan
for the Left Bank of Chao Phraya River

SCALE
1/200,000

LEFT BANK
CASE-1

WATER SOURCE

WELL 26,650CMD

CENTRAL 166,450CMD

LEGENT	
Fa ; Factory Area	○
Ho ; Housing Area	○
1st Stage Pipe Line	—
2nd Stage Pipe Line	---
Reservoir Pump Station Unit	□
Distribution Pump Station at Treatment Plant	▨
Well	⊙
Intake site	⊕
Transmission Pipe Line	—

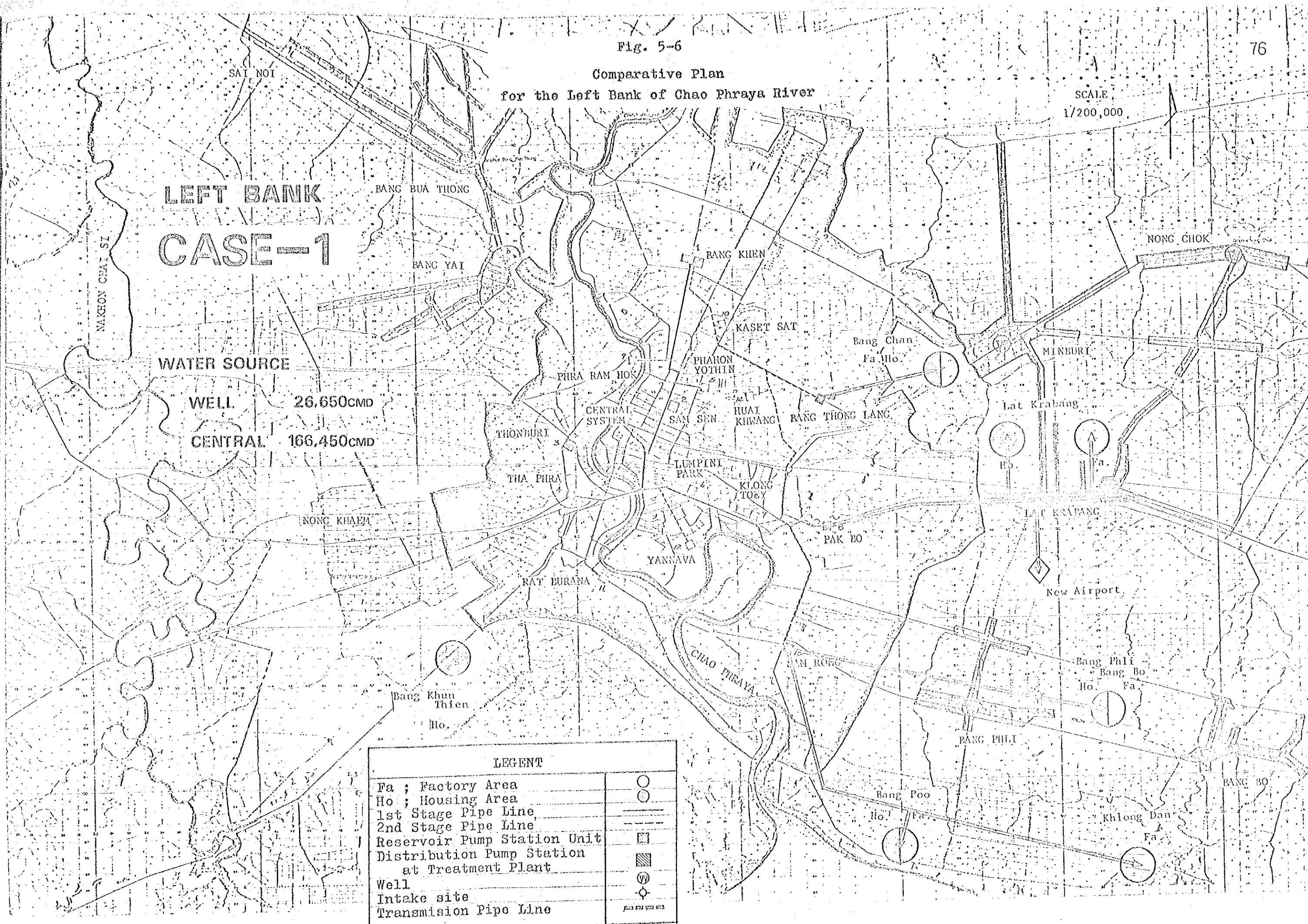


Fig. 5-7

Comparative Plan
for the Left Bank of Chao Phraya River

SCALE
1/200,000

LEFT BANK
CASE - 2

WATER SOURCE

WELL 26,650CMD

KHLONG 166,450CMD

LEGENT	
Fa ; Factory Area	○
Ho ; Housing Area	○
1st Stage Pipe Line	—
2nd Stage Pipe Line	—
Reservoir Pump Station Unit	□
Distribution Pump Station at Treatment Plant	▨
Well	⊙
Intake site	⊙
Transmission Pipe Line	—

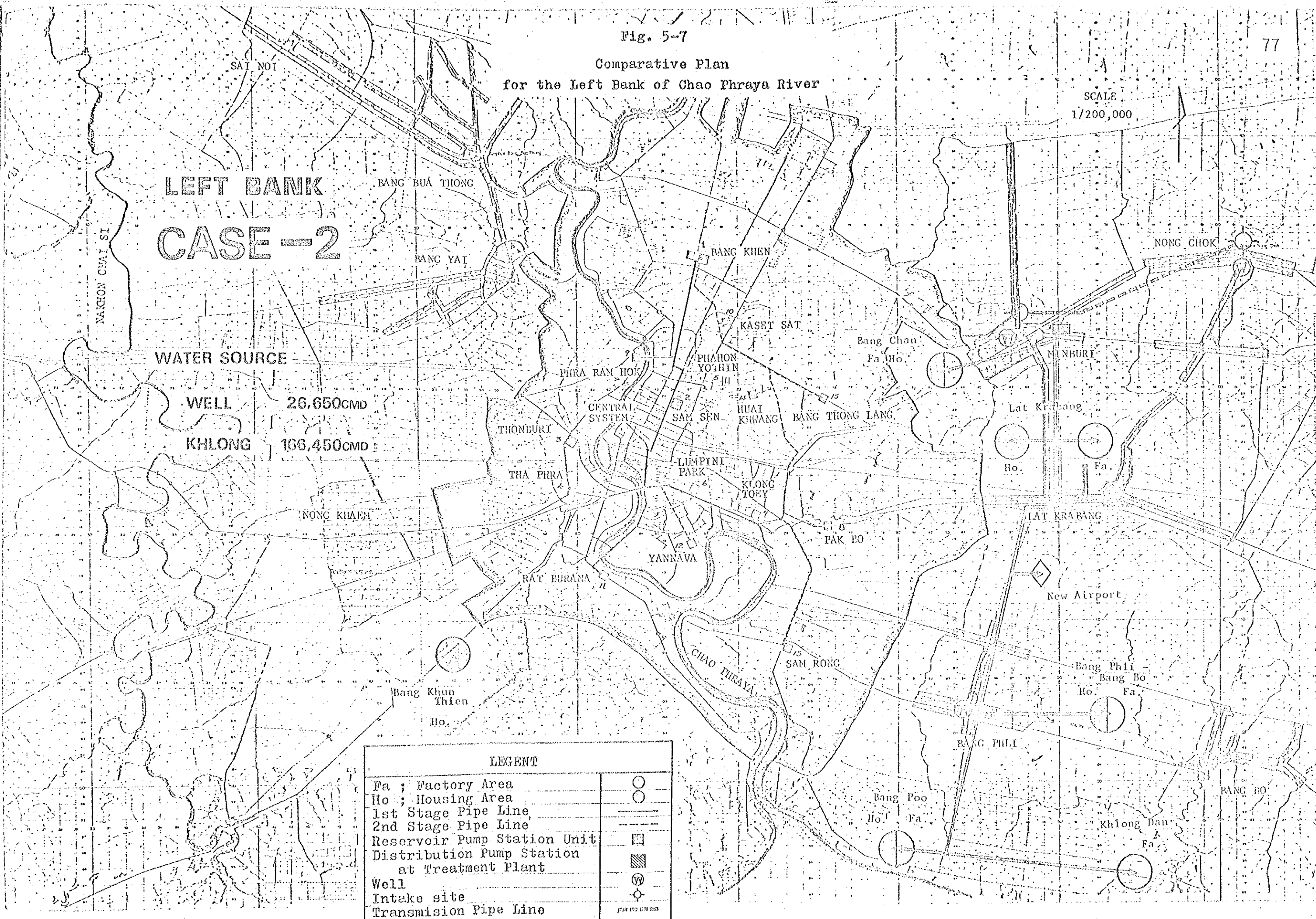


Fig. 5-8

Comparative Plan
for the Left Bank of Chao Phraya River

SCALE
1/200,000

LEFT BANK
CASE-3

WATER SOURCE
CENTRAL 193,100CMD

LEGENT	
Fa ; Factory Area	○
Ho ; Housing Area	○
1st Stage Pipe Line	—
2nd Stage Pipe Line	---
Reservoir Pump Station Unit	□
Distribution Pump Station at Treatment Plant	▣
Well	⊙
Intake site	⊕
Transmission Pipe Line	—

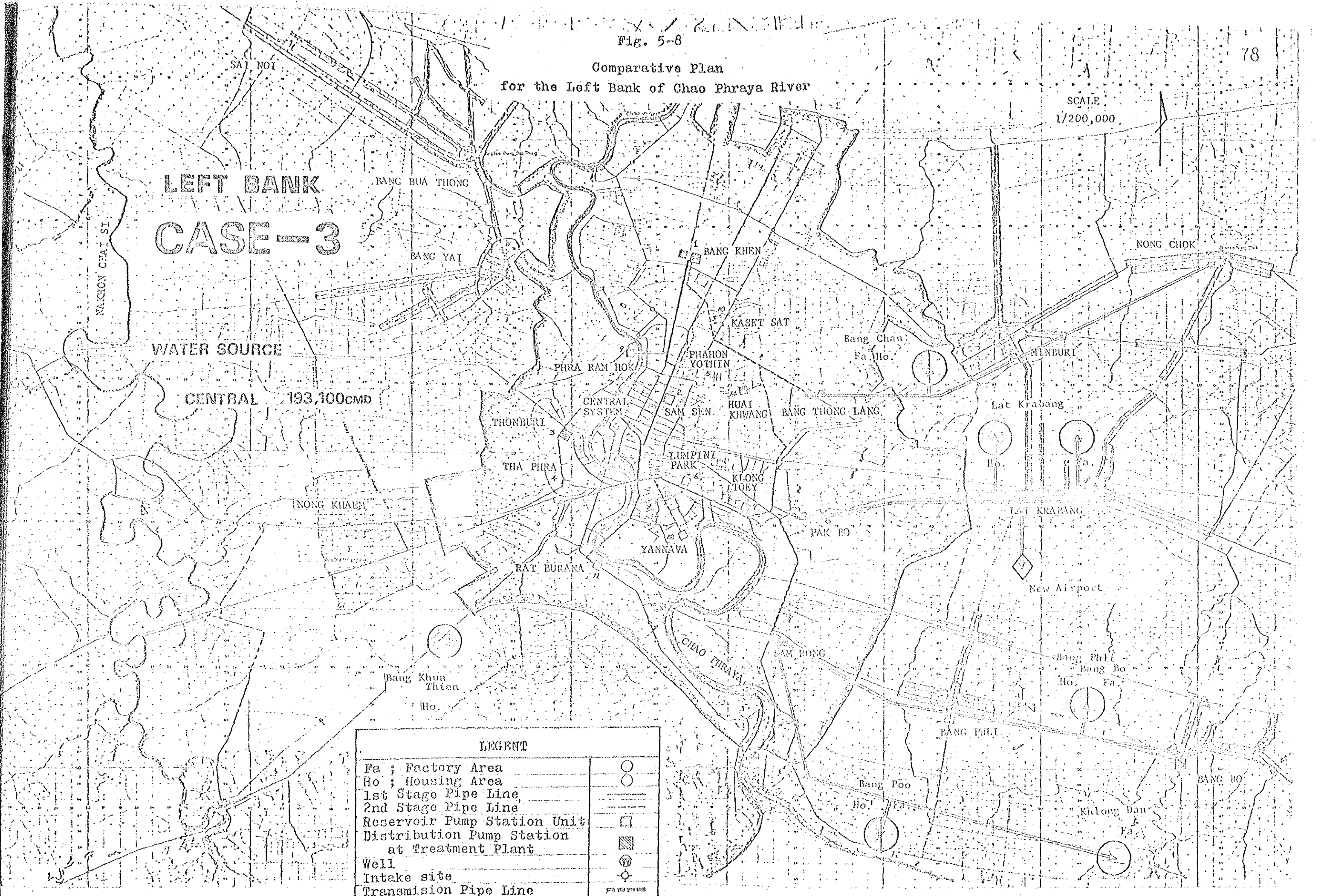


Fig. 5-9

Comparative Plan
for the Left Bank of Chao Phraya River

SCALE
1/200,000

LEFT BANK
CASE-4

WATER SOURCE

KHLONG 193,100CMD

LEGEND	
Fa ; Factory Area	○
Ho ; Housing Area	○
1st Stage Pipe Line	—
2nd Stage Pipe Line	—
Reservoir Pump Station Unit	□
Distribution Pump Station at Treatment Plant	▨
Well	⊙
Intake site	◇
Transmission Pipe Line	—

