2.4 WATER SOURCES

2.4.1 Groundwater

The present source of water used for the Hanoi public water supply system is groundwater exploited from a confined aquifer (almost all from so called Pleistocene or Lower aquifer: Qa) in Quaternary deposits laying beneath the city.

(1) Main Groundwater Wellfields

There are totally 104 wells (about 60-70 m deep) providing water to the Hanoi water supply system. Those wells are located in the wellfields around the main eight (8) treatment plants managed by HWBC. The main groundwater wellfields and their pumping discharge are presented in Table 2.4-1. Location map of the wellfields is shown in Fig. 2.4-1.

Table 2.4-1 Main Groundwater Wellfields and Their Pumping Discharge

No.	Name of Wellfields	Number of Wells	Pumping Discharge (m^3/d)	Feasible Discharge (m3/d)
1	Yen Phu	13	44,500	110,000
2	Ngo Si Lien	19	43,200	30,000
3	Ngoc Ha	11	50,300	30,000
4	Phap Van	9	27,700	30,000
5	Mai Dich	18	64,200	45,000
6	Ha Dinh	9	27,200	25,000
7	Luong Yen	15	79,500	80,000
8	Tuong Mai	10	29,200	30,000
	Total	104	365,800	380,000

Note: 1) Figures as of 1995.
2) Pumping Discharge means raw water discharge calculated as 110% of the treated water.
3) Number of Wells includes standby wells.
4) The column "Feasible Discharge" shows the most feasible discharge which was reported in "FINNIDA M/P, 1993" and approved by the Government.

Actual pumping discharges of Ngo Si Lien, Ngoc Ha and Mai Dich considerably exceed the most feasible discharge.

It can be said that environmental impacts such as land subsidence tend to occur in and around these three wellfields.

(2) Small Wellfields

In addition to the above mentioned main plants, there exist 15 small wellfields which are managed by the five (5) enterprises under HWBC. Those small wellfields are listed in Table 2.4-2. Location map of the small wellfields is shown in Fig. 2.4-1 together with the main wellfields.

Table 2.4-2 Small Wellfields and Their Pumping Discharge

No.	Name of Enterprises & Wellfields	Number of Wells	Pumping Discharge (m^3/d)
I.	Ba Dinh	(7)	(2,000)
1	H31 An Duong	1	1,200
2	Thuy Khue	6	800
II.	Hoan Kiem	(6)	(12,200)
1	Don Thuy	3	7,800
2	Thuy Loi	2	1,100
3	Phuc Tan	1	3,300
III.	Dong Da	(8)	(4,900)
1	Bach Mai	3	2,200
2	KH. Trung	2	700
3	Kim Giang	2	1,500
4	Giap Bat	1	500
IV.	Hai Ba Trung	(5)	(6,400)
1	Bach Khoa	2	1,800
2	Quynh Mai	2	2,100
3	Van Don	1	2,500
V.	Gia Lam	(7)	(9,000)
1	Gia Lam	2	5,200
2	Sai Dong	2	1,100
3	Dong Anh	3	2,700
	Total	V/33	34,500

Note: 1) Figures as of 1995.
2) Pumping Discharge means raw water discharge calculated as 110% of the treated water.
3) Number of Wells includes standby wells.
4) "2.Thuy Khue" in "I.Ba Dinh" is not under HWBC. HWBC buys the water of 800 m^3/d from the plant.

(3) Private Wells

Furthermore, approximately 300 private wells possessed by about 240 owners are identified in the study area. They are being operated continuously or discontinuously, also discharging from the lower aquifer Qa, and supplying water to institutions, factories, domestic purposes, etc. Table 2.4-3 shows the number of private wells and their discharge in each district.

Table 2.4-3 Number of Private Wells and Their Discharge in Each District

No.	Name of Districts	Number of Wells	Pumping Discharge (m^3/d)	Estimated Discharge (m^3/d)
I.	South Hanoi	184	78,900	100,000
(1)	Tu Liem	(80)	(9,900)	-
(2)	Thanh Tri	(50)	(18,800)	-
(3)	Hai Ba Trung	(18)	(19,400)	-
(4)	Ba Ding	(11)	(16,900)	-
(5)	Dong Da	(25)	(13,900)	-
II.	Soc Son	9	2,400	6,000
III.	Dong Anh	31	10,100	10,000
IV.	Gia Lam	76	13,200	13,000
Total		300	104,600	129,000

Note: 1) Figures are based on the data of K2(1994) and HWBC(1995)
2) Estimated Discharge is estimated considering the data of HWBC and the results of sample survey by interview in this study.

(4) Water Use for Water Supply

Present water use for water supply (groundwater) in each area is tabulated in Table 2.4-4.

Table 2.4-4 Present Water Use in Each Area(m^3/s)

Name of Area	Public (HWBC)	Public (Enterprise)	Private	Total
Soc Son	-	-	6,000	6,000
Dong Anh	-	3,000	10,000	13,000
Gia Lam	-	6,000	13,000	19,000
South Hanoi	370,000	30,000	100,000	500,000
Total	370,000	39,000	129,000	538,000

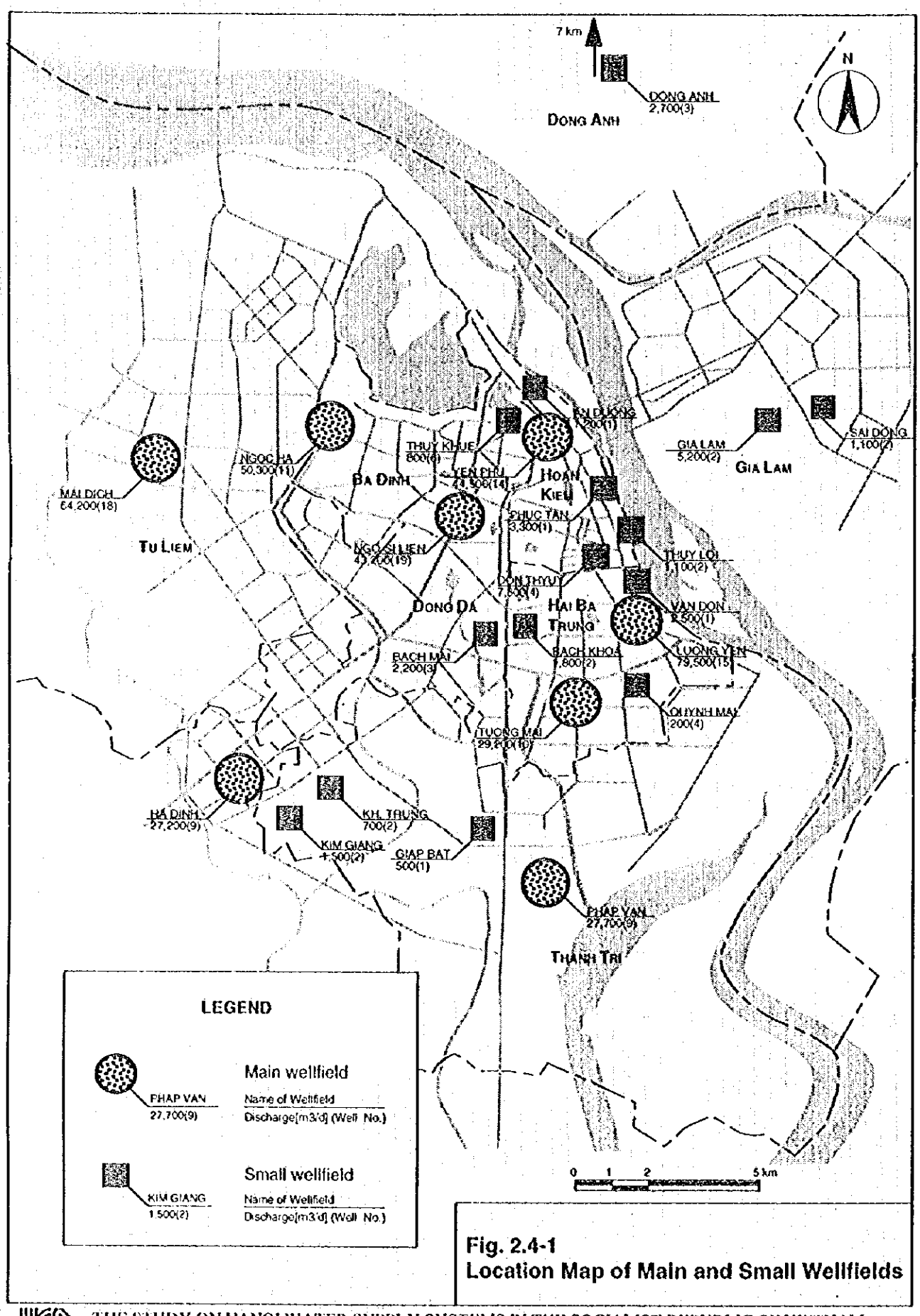


Fig. 2.4-1
Location Map of Main and Small Wellfields

2.4.2 Water Quality

(1) Water Quality Criteria

There are some effective water quality criteria in Vietnam that are described in "Provisional Environmental Criteria" (issued by MOSTE in 1993) and "Vietnamese Environmental Standards" (issued by MOSTE in 1995). Criteria on drinking water, water supply and environment are chosen and shown in tables in Appendix. In these tables, WHO's guidelines are attached for reference.

As for criteria for drinking water, same limit values as WHO's guidelines are adopted for most parameters prescribed in Vietnamese criteria. As for criteria for raw water, groundwater should be evaluated by "criteria for water supply" and surface water should be evaluated by "water quality standard (class A for surface water)".

(2) Water Quality of the Sources for Water Supply

Fig. 2.4-2 and Table 2.4-5 show averaged water quality characteristics of the existing public/private production wells or observation wells.

In general, concentration values of iron and manganese are high and do not meet the requirements of the criteria for drinking water or the criteria for water supply in the whole city. The concentration of iron tends to show higher values in the southern part of the south Hanoi, Gia Lam district and Dong Anh district. Manganese tends to show higher values in the northern part of the south Hanoi, however the values in the Soc Son district seem to meet the criteria. Ammonia in the southern part of the south Hanoi shows higher values and does not meet the criteria for drinking water or the criteria for water supply. Distribution pattern of organic matter concentration seems to be similar to that of ammonia concentration.

1) South Hanoi

Water quality of existing HWBC's production wells is monitored by the laboratory of HWBC with a frequency of twice a year. Analyzed results in the last five years (from the middle of 1990 to the middle of 1995) are compiled in some tables and figures to understand characteristics of groundwater.

Table 2.4-6 shows averaged water quality characteristics of existing production wells/wellfields in the south Hanoi. Data are derived from two sources; one is a result periodically monitored by the laboratory of HWBC and the other is a result occasionally surveyed in this study. Locations of the private wells surveyed in this study are shown in Fig. 2.4-3. Additionally, statistically arranged data for each HWBC's production wells are shown in Appendix. The characteristics of groundwater quality are summarized as follows.

pH

Averages of all wellfields meet the requirements of the criteria for drinking water and the criteria for water supply.

Ammonia

Higher averages over the criteria (3.0mg/l) for drinking water are shown in the southern part of the south Hanoi. The highest average of 19.7mg/l was observed in Phap Van wellfield, and the highest maximum of 60.0mg/l was observed in Tuong Mai wellfield. As for ammonia, there is no criterion for water supply, but averages in three southern wellfields exceed the Vietnamese criteria for drinking water. On the other hand, ammonia concentration does not exceed the criteria for drinking water in the northern part of the south Hanoi.

Nitrate

Averages in all wellfields meet the maximum requirement (≦25mg/l) for water supply and the criteria (≦10mg/l) for drinking water. Comparatively higher averages tend to be shown in the northern part of the south Hanoi except Yen Phu wellfield.

Iron

Averages of all wellfields in the south Hanoi exceed the criteria (≦0.3mg/l) for drinking water. Values of the southern part of the south Hanoi tend to be higher than those of the northern part. Higher averages over the minimum requirement (10mg/l) for water supply are shown in the southern part of the area. The highest average of 11.4mg/l is observed in Ha Dinh wellfield, and the highest maximum of 27mg/l is observed in Tuong Mai wellfield. In the northern part of the area, averages are lower and generally satisfy the maximum requirement (≦3mg/l) for water supply.

Hardness

All data satisfy the maximum requirement (≦300mg/l) for water supply. The highest average of 11°G (=197mg/l) among all wellfields is observed in Yen Phu, and higher averages seem to be shown in the core of the central Hanoi.

Manganese

Higher averages over the minimum requirement (0.5mg/l) for water supply are shown in the northern part of the south Hanoi. The highest average of 1.1mg/l is observed in Ngoc Ha wellfield, and the highest maximum of 2.9mg/l is observed in Yen Phu wellfield. In the southern part of the area, averages are lower and generally satisfy the maximum requirement (≦ 0.3mg/l) for water supply. Averages of Ha Dinh and Phap Van meet the criteria (≦3mg/l) for drinking water.

Organic Matter

As same as ammonia, averages of the southern part of the south Hanoi tend to be higher than those of the northern part. This local distribution of high concentration of ammonia and organic matter suggests that high concentration of ammonia relates to the existence of scattered geologic layers with peat or organic matters.

Toxic Substances

Data are not enough to understand probable concentration of toxic substances, because the data were obtained by only one time sampling. Data for most parameters show that groundwater in the area seems to satisfy the minimum requirement for water supply and the criteria for drinking water, however

cadmium (Cd) and lead (Pb) do not meet the criteria for drinking water in some wells/wellfields. As for phenol, only a private well of Mine-geology University exceptionally does not satisfy the standard (≦0.001mg/l) for environment.

2) North Hanoi

Compared with the south Hanoi, there are not enough data in the north Hanoi to understand groundwater quality characteristics clearly. Table 2.4-7 and Table 2.4-8 show water quality characteristics of existing several observation wells, five (5) production wells and raw groundwater transmitted to a HWBC's water treatment plant. Private production wells except SSPC were occasionally surveyed in this study. Locations of these wells are shown in Fig. 2.4-3. Additionally, statistically arranged data for each wells are shown in Appendix. The characteristics are summarized as follows.

pH

The average of pH in Dong Anh district meets the minimum requirement (6.0 ~8.0) for water supply, however it is slightly smaller than the criteria (6.5~ 8.5) for drinking water. In general, groundwater shows slightly acid due to free carbon dioxide (CO_2) generated by microbiological activities in the ground.

Ammonia

On average, ammonia of the north Hanoi meets the criteria (≦3.0mg/l) for drinking water and is much lower than that of the southern part of the south Hanoi. Differences of concentration among the districts are not so big.

Nitrate

Averages of all wells satisfy the maximum requirement (≦25mg/l) for water supply and the criteria (≦10mg/l) for drinking water.

Iron

The averages of each district do not meet the criteria (≦0.3mg/l) for drinking water. Higher averages were observed in Gia Lam district and Dong Anh district as compared with Soc Son district. Some wells show higher values

over the minimum requirement (≦10mg/l) for water supply.

Hardness

Although data of only a few wells can be available for each districts, the values of hardness meet the maximum requirements (≦300mg/l) for water supply and the criteria (≦500mg/l) for drinking water.

Manganese

Although available data are limited, manganese shows a little high concentration in Dong Anh district and Gia Lam district. Averages of these two districts meet the maximum requirement (≦0.3mg/l) for water supply, however they do not meet the criteria (≦0.1mg/l) for drinking water.

Organic Matter

Concentration of organic matter is lower than that of the southern part of the south Hanoi, same as ammonia is.

Toxic Substances

Data are not enough to understand probable concentration of toxic substances, because the data were obtained from only a few wells for each district by only one sampling. Data for most parameters show that groundwater in the area seems to satisfy the minimum requirement for water supply and the criteria for drinking water. However concentration values of cadmium (Cd) do not meet the criteria (≦0.005mg/l) for drinking water in Dong Anh district and Gia Lam district. The values of lead (Pb) do not meet the criteria (≦0.05mg/l) for drinking water either in a few wells. As for phenol, private wells of two (2) factories in Dong Anh district and Gia Lam district do not satisfy the standard (≦0.001mg/l) for environment.

Further water quality monitoring of these water sources will be necessary for more reliable conclusion.

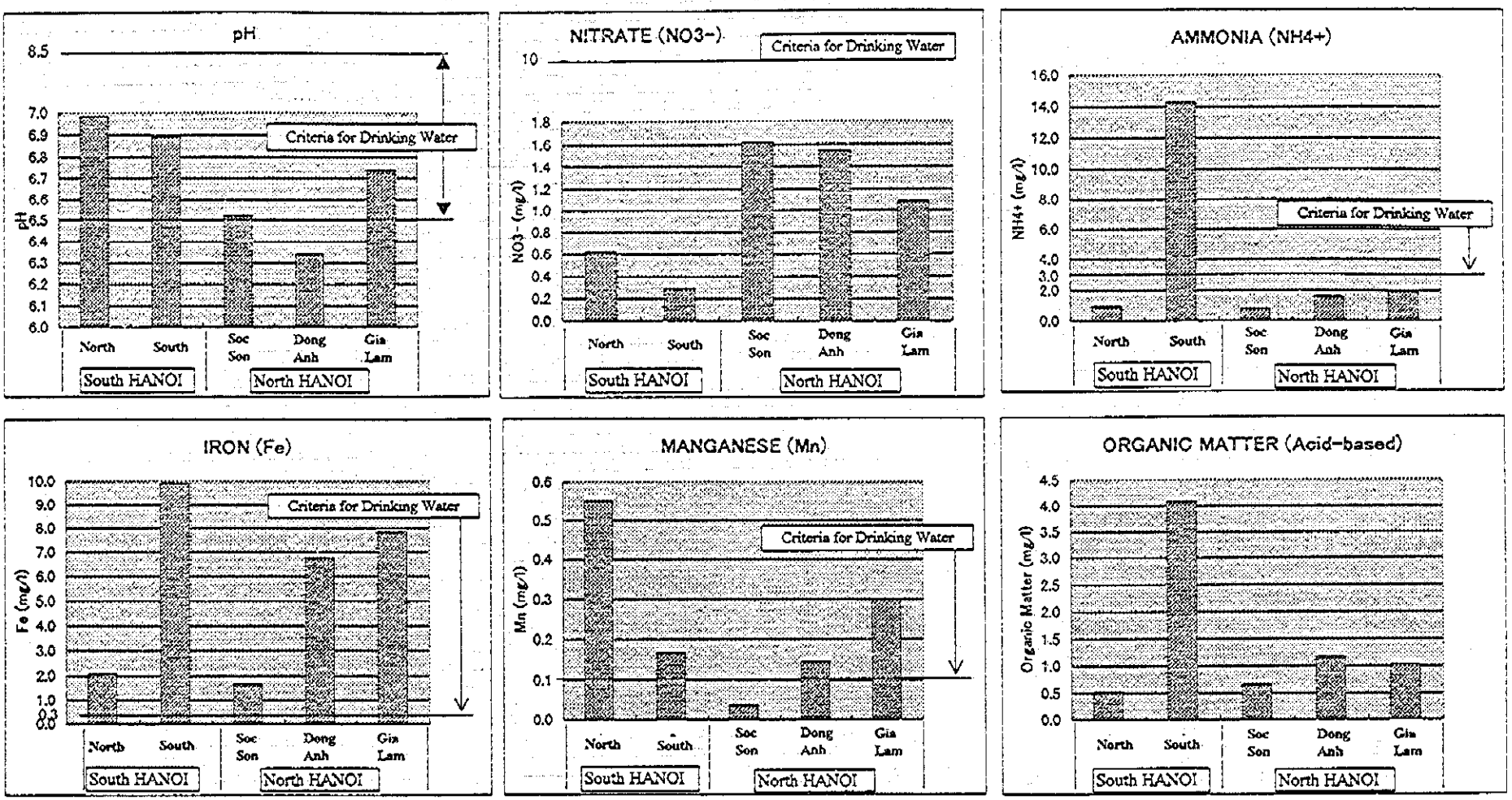


Fig. 2.4-2 Groundwater Quality Characteristics in Hanoi

Table 2.4-5 Groundwater Quality in Hanoi (Average)

Region		Groundwater Quality					Water Quality Criteria				
		South Hanoi		North Hanoi			Criteria for Drinking Water			Criteria for Water Supply	
Area		North	South	Soc Son	Dong Anh	Gia Lam	Urban	Distribution & Rural	WHO's Guidelines	Min. Requirement	Max. Requirement
Parameter	Unit										
pH		7.0	6.9	6.5	6.3	6.7	6.5~8.5	6.5~8.5	-	6.0~8.0	6.5~8.0
NH_4^+	mg/l	0.9	14.3	0.8	1.5	2.0	3.0	3.0	1.5	-	-
NO_3^-	mg/l	0.6	0.3	1.6	1.5	1.1	10	10	50	50	25
Fe	mg/l	2.1	9.9	1.7	6.8	7.8	0.3	0.5	0.3	10	3
Hardness	°G	8	7	-	-	-	-	-	-	-	-
($CaCO_3$)	mg/l	174	-	118	155	198	500	500	-	500	300
Mn^{2+}	mg/l	0.6	0.2	0.0	0.1	0.3	0.1	0.1	0.1	0.5	0.3
Organic matter (Acid-based)	mg/l	0.5	4.1	0.7	1.2	1.0	-	-	-	-	-

Note: 1) The unit "°G" of Hardness is German degree; 1°G is equivalent to 17.9mg/l($CaCO_3$).

Table 2.4-6 Ground Water Quality in the South Hanoi

Code No. of Well Fields/Wells		North							South			Water Quality Criteria					
		HWBC's Well Fields					Private Wells		HWBC's Well Fields								
		MD	NH	YP	NSL	LY	J5	J6	TM	HD	PV						
Sampling Period		1990.8~ 1996.7, 1996.7	1989.5~ 1996.3, 1996.7	1988.12~ 1996.5, 1996.7	1989.7 ~ 1995.12, 1996.7	1990.3~ 1996.5, 1996.7	1996.7	1996.7	1989.4~ 1996.5, 1996.7	1990.4~ 1996.5, 1996.7	1989.10~ 1996.4, 1996.7	Standard for Environment (TCVN5944-1995)	Criteria for Water Supply		Criteria for Drinking Water		
Sampling Frequency		4~11, 1	8~16, 1	7~16, 1	7~16, 1	1~12, 1	1	1	6~15, 1	8~12, 1	8~13, 1		Min. Requirement	Max. Requirement	Urban	Distribution System & Rural	WHO's Guidelines
Parameter	Unit	Concentration (Average)															
pH		6.6	6.7	7.2	6.7	7.7	-	-	6.8	6.9	7.0	6.5~8.5	6.0~8.0	6.5~8.0	6.5~8.5	6.5~8.5	-
NH_4^+	mg/l	0.0	0.7	2.8	1.5	1.0	0.4	0.2	10.4	12.8	19.7	-	-	-	3.0	3.0	1.5
NO_3^-	mg/l	1.3	0.9	0.2	0.7	0.4	0.3	0.7	0.3	0.4	0.2	45	50	25	10	10	50
Fe	mg/l	0.7	1.6	3.7	3.1	1.8	3.2	0.4	10.3	11.4	8.1	1.0~5.0	10	3	0.3	0.5	0.3
Hardness	°G	5	9	11	9	7	-	-	7	8	8	-	-	-	-	-	-
($CaCO_3$)	mg/l	-	-	-	-	-	228	121	-	-	-	300~500	500	300	500	500	-
Mn^{2+}	mg/l	0.7	1.1	0.6	1.0	0.2	0.2	0.1	0.3	0.1	0.1	0.1~0.5	0.5	0.3	0.1	0.1	0.1
Organic matter (Acid-based)	mg/l	0.3	0.5	0.8	0.7	0.4	-	-	2.9	3.0	6.3	-	-	-	-	-	-
TS	mg/l	-	-	-	-	-	184	60	-	-	-	750~1,500	-	-	-	-	-
SO_4^{2-}	mg/l	-	-	-	-	-	100	20	-	-	-	200~400	250	250	400	400	250
Phenol	mg/l	0.000	0.000	0.000	0.000	0.000	0.007	0.000	0.000	0.000	0.000	0.001	-	-	-	-	-
As	mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.1	0	0.05	0.05	0.01
Zn	mg/l	0.5	0.6	0.4	0.5	0.5	0.1	0.0	0.6	0.7	0.6	5	5	1	5	5	3
Cd	mg/l	0.004	0.006	0.007	0.005	0.008	0.009	0.005	0.006	0.004	0.006	0.01	0.01	0	0.005	0.005	0.003
Pb	mg/l	0.03	0.09	0.12	0.08	0.16	0.07	0.02	0.12	0.08	0.12	0.05	0.05	0	0.05	0.05	0.01
CN	mg/l	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.05	0	0.1	0.1	0.07
Hg	mg/l	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0	0.001	0.001	0.001
Cu	mg/l	-	-	-	-	-	0.17	0.18	-	-	-	1.0	1.5	0.05	1	1	1 (complaint) 2 (health)
Cr(total)	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	0.05	0.05
Cr(VI)	mg/l	-	-	-	-	-	0.01	0.00	-	-	-	0.05	-	-	-	-	-
F	mg/l	-	-	-	-	-	0.81	0.45	-	-	-	1.0	1.5	0.75	1.5	1.5	1.5

Note: 1) Name of well fields: MD (Mai Dich) , NH (Ngoc Ha) , YP (Yen Phu) , NSL (Ngo Si Lien) , LY (Luong Yen) , TM (Tuong Mai) , HD (Ha Dinh) , PV (Phap Van)

2) Name of private production wells: J5 (Regst. No.77: Mine-geology university) , J6 (regst. No.61: Hanoi textile co.)

3) The unit "°G" of Hardness is German degree; 1°G is equivalent to 17.9mg/l($CaCO_3$).

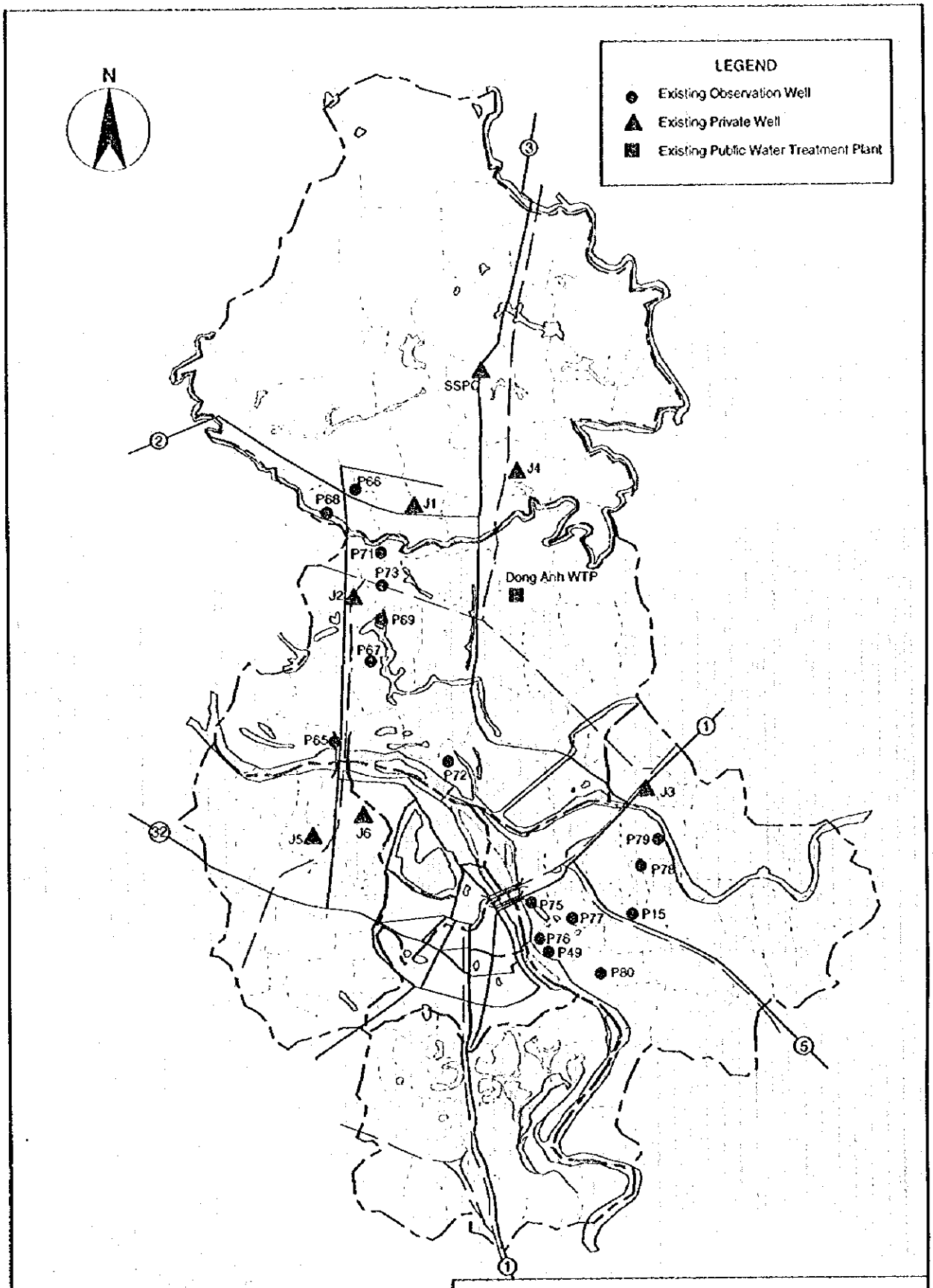


Fig. 2.4-3 Location Map of Occasionally Surveyed Wells

Table 2.4-7 Ground Water Quality in the North Hanoi (Soc Son and Dong Anh)

Code No. of Wells		Soc Son District					Dong Anh District								Water Quality Criteria					
		P66a	P68a	SSPC	J1	J4	P71a	P73a	P69a	P67a	P65a	P72a	J2	WTP	Standard	Criteria for Water Supply		Criteria for Drinking Water		
Sampling Period		1994.9 ~ 1995.9	1994.9 ~ 1995.9	1995.6	1996.7	1996.7	1993.9 ~ 1995.9	1995.9	1993.9 ~ 1995.9	1994.9 ~ 1995.9	1993.9 ~ 1995.9	1993.9 ~ 1995.9	1996.7	1996.7	for	Min.	Max.	Urban	Distribution System & Rural	WHO's
Sampling Frequency		2	2	1	1	1	4	1	4	2	4	4	1	1	Environment	Requirement	Requirement			Guidelines
Parameter	Unit	Concentration (Average)													(TCVN5944-1995)					
pH		5.9	6.3	7.4	-	-	6.1	6.1	6.0	6.8	6.5	6.6	-	-	6.5~8.5	6.0~8.0	6.5~8.0	6.5~8.5	6.5~8.5	-
NH_4^+	mg/l	3.4	0.4	0.1	0.0	0.0	0.4	6.0	0.8	1.5	3.1	0.2	0.1	0.3	-	-	-	3.0	3.0	1.5
NO_3^-	mg/l	1.3	3.0	1.0	1.2	1.7	0.3	2.5	0.4	4.1	1.2	1.0	0.1	2.8	45	50	25	10	10	50
Fe	mg/l	2.0	5.6	0.4	0.1	0.2	5.8	15.0	5.8	12.4	6.0	2.6	3.9	2.5	1.0~5.0	10	3	0.3	0.5	0.3
Hardness	°G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
($CaCO_3$)	mg/l	-	-	110	140	104	-	-	-	-	-	-	148	161	300~500	500	300	500	500	-
Mn^{2+}	mg/l	-	-	0.0	0.0	0.1	-	-	-	-	-	-	0.1	0.2	0.1~0.5	0.5	0.3	0.1	0.1	0.1
Organic matter (Acid-based)	mg/l	0.6	1.0	0.5	-	-	1.0	0.6	0.6	1.4	2.6	0.8	-	-	-	-	-	-	-	-
TS	mg/l	-	-	-	102	129	-	-	-	-	-	-	108	185	750~1,500	-	-	-	-	-
SO_4^{2-}	mg/l	-	-	5	12	12	-	-	-	-	-	-	120	82	200~400	250	250	400	400	250
Phenol	mg/l	-	-	-	0.000	0.000	-	-	-	-	-	-	0.050	0.000	0.001	-	-	-	-	-
As	mg/l	-	-	-	0.00	0.00	-	-	-	-	-	-	0.00	0.00	0.05	0.1	0	0.05	0.05	0.01
Zn	mg/l	-	-	-	0.1	0.5	-	-	-	-	-	-	0.1	0.9	5	5	1	5	5	3
Cd	mg/l	-	-	-	0.004	0.005	-	-	-	-	-	-	0.006	0.025	0.01	0.01	0	0.005	0.005	0.003
Pb	mg/l	-	-	-	0.03	0.10	-	-	-	-	-	-	0.04	0.06	0.05	0.05	0	0.05	0.05	0.01
CN	mg/l	-	-	-	0.00	0.00	-	-	-	-	-	-	0.00	0.00	0.01	0.05	0	0.1	0.1	0.07
Hg	mg/l	-	-	-	0.000	0.000	-	-	-	-	-	-	0.000	0.000	0.001	0.001	0	0.001	0.001	0.001
Cu	mg/l	-	-	-	0.07	0.08	-	-	-	-	-	-	0.07	0.32	1.0	1.5	0.05	1	1	1 (complaint) 2 (health)
Cr(total)	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.05	0.05	0.05
Cr(VI)	mg/l	-	-	-	0.00	0.00	-	-	-	-	-	-	0.03	0.00	0.05	-	-	-	-	-
F	mg/l	-	-	-	0.31	0.41	-	-	-	-	-	-	0.83	0.85	1.0	1.5	0.75	1.5	1.5	1.5

Note:
1) Name of observation wells: "P" shows a code of observation well managed by HWBC, and "a" shows a water sample from the aquifer Qa.
2) Name of private production wells: SSPC (the premise of Soc Son People's Committee) , J1 (Regst. No.505: Kim Anh tea factory) , J2 (Regst. No.502: Nam Hong mechanical factory) , J4 (Practical school for workers)
3) Name of water treatment plant: WTP (raw water sample before treatment taken from the Dong Anh water treatment plant)
4) The unit "°G" of Hardness is German degree; 1°G is equivalent to 17.9mg/l($CaCO_3$).

Table 2.4-8 Ground Water Quality in the North Hanoi (Gia Lam)

Code No. of Wells		Gia Lam District									Water Quality Criteria					
		P79a	P78a	P15a	P77a	P80a	P75a	P76a	P49a	J3	Standard	Criteria for Water Supply		Criteria for Drinking Water		
Sampling Period		1994.3~1995.9	1995.9	1992.7~1995.9	1994.9~1995.9	1993.9~1995.9	1993.9~1995.9	1993.9~1995.9	1992.9~1995.9	1996.7	for Environment (TCVN5944-1995)	Min. Requirement	Max. Requirement	Urban	Distribution System & Rural	WHO's Guidelines
Sampling Frequency		3	1	7	2	4	4	4	7	1						
Parameter	Unit	Concentration (Average)														
pH		6.7	6.5	6.6	6.6	6.7	6.6	7.1	7.2	-	6.5~8.5	6.0~8.0	6.5~8.0	6.5~8.5	6.5~8.5	-
NH_4^+	mg/l	0.7	0.3	2.1	0.8	3.5	0.2	6.0	3.1	1.0	-	-	-	3.0	3.0	1.5
NO_3^-	mg/l	5.1	1.0	0.5	0.5	0.4	1.0	0.6	0.4	0.3	45	50	25	10	10	50
Fe	mg/l	5.1	8.0	7.9	14.2	7.4	2.6	12.3	7.6	5.5	1.0~5.0	10	3	0.3	0.5	0.3
Hardness	°G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
($CaCO_3$)	mg/l									198	300~500	500	300	500	500	-
Mn^{2+}	mg/l	-	-	-	-	-	-	-	-	0.3	0.1~0.5	0.5	0.3	0.1	0.1	0.1
Organic matter (Acid-based)	mg/l	0.9	1.1	1.5	0.8	1.0	0.8	1.1	1.1	-	-	-	-	-	-	-
TS	mg/l	-	-	-	-	-	-	-	-	303	750~1,500	-	-	-	-	-
SO_4^{2-}	mg/l	-	-	-	-	-	-	-	-	41	200~400	250	250	400	400	250
Phenol	mg/l	-	-	-	-	-	-	-	-	0.007	0.001	-	-	-	-	-
As	mg/l	-	-	-	-	-	-	-	-	0.00	0.05	0.1	0	0.05	0.05	0.01
Zn	mg/l	-	-	-	-	-	-	-	-	0.4	5	5	1	5	5	3
Cd	mg/l	-	-	-	-	-	-	-	-	0.008	0.01	0.01	0	0.005	0.005	0.003
Pb	mg/l	-	-	-	-	-	-	-	-	0.14	0.05	0.05	0	0.05	0.05	0.01
CN	mg/l	-	-	-	-	-	-	-	-	0.00	0.01	0.05	0	0.1	0.1	0.07
Hg	mg/l	-	-	-	-	-	-	-	-	0.000	0.001	0.001	0	0.001	0.001	0.001
Cu	mg/l	-	-	-	-	-	-	-	-	0.02	1.0	1.5	0.05	1	1	1 (complaint) 2 (health)
Cr(total)	mg/l	-	-	-	-	-	-	-	-	-	-	-	-	0.05	0.05	0.05
Cr(VI)	mg/l	-	-	-	-	-	-	-	-	0.01	0.05	-	-	-	-	-
F	mg/l	-	-	-	-	-	-	-	-	0.54	1.0	1.5	0.75	1.5	1.5	1.5

Note: 1) Name of observation wells: "P" shows a code of observation well managed by HWSC, and "a" shows a water sample from the aquifer Qa.

2) Name of private production wells: J3 (Regst. No.521: Yen Vien shoes co.)

3) The unit "°G" of Hardness is German degree; 1°G is equivalent to 17.9mg/l($CaCO_3$).

2.5 WATER SUPPLY FACILITIES

2.5.1 Water Production and Consumption

Based on the HWBC's latest data (January-June 1996) on water production and consumption, their fundamental figures are as follows, on the daily average basis.

(a) Production capacity = 370,000 m3/day (100%)
(b) Billed water = 192,500 m3/day (52.0% of (a))
(c) HWBC's own use = 400 m3/day (0.1% of (a))

(Note)
(b) Billed water is calculated based on the following assumptions:
(b1) Billing water records (107,829 m3/d : 29.1% of (a))
From the monthly billing records, water consumption by customers' category are identified. It is 107,829 m3/d in total. As for customers using flat rate, their consumption are calculated as 4 m3/person/month.
(b2) Estimation on excessive use on flat rate (84,651 m3/d : 22.9% of (a))
Excessive use on flat rate over 4 m3/person are estimated to be 84,651 m3/d in total.

Water loss can be calculated as follows :
Total loss = (a) - (b + c) = 370,000 - (192,500 + 400)
= 177,100 m3/day (47.9% of (a)).

The above loss is consisted of physical loss and administration loss.
The physical loss is estimated to be 25% of the production capacity as a result of the leakage survey.

It was found by the leakage survey carried out in April-May 1996 that rates of physical leakage in pipelines constructed or replaced during recent yeas of 1985-1995 were approximately 10-15% estimated.

In several areas where pipelines were installed before 1985, rates of leakage are estimated to be higher rates of about 30%.

It could be concluded that in the whole city, consisting of old pipe areas and new pipe areas, the rate of physical leakage was 20-25%, or rather 25% on average.

Leakage Survey Result

No.	Block Name	Physical Loss (Estimated) (%)
1	Yen Phu	15 – 20
2	Quan Ngua	5 – 10
3	Lang Thuong	15 – 20
4	Thuong Dinh	5 – 10
5	Phap Van	5 – 10
6	An Son	15 – 20
7	Huong Vien	20 – 30
8	221 Nguyen Khuyen	15 – 20

For more detail, please refer to "Water Leakage Survey Report".

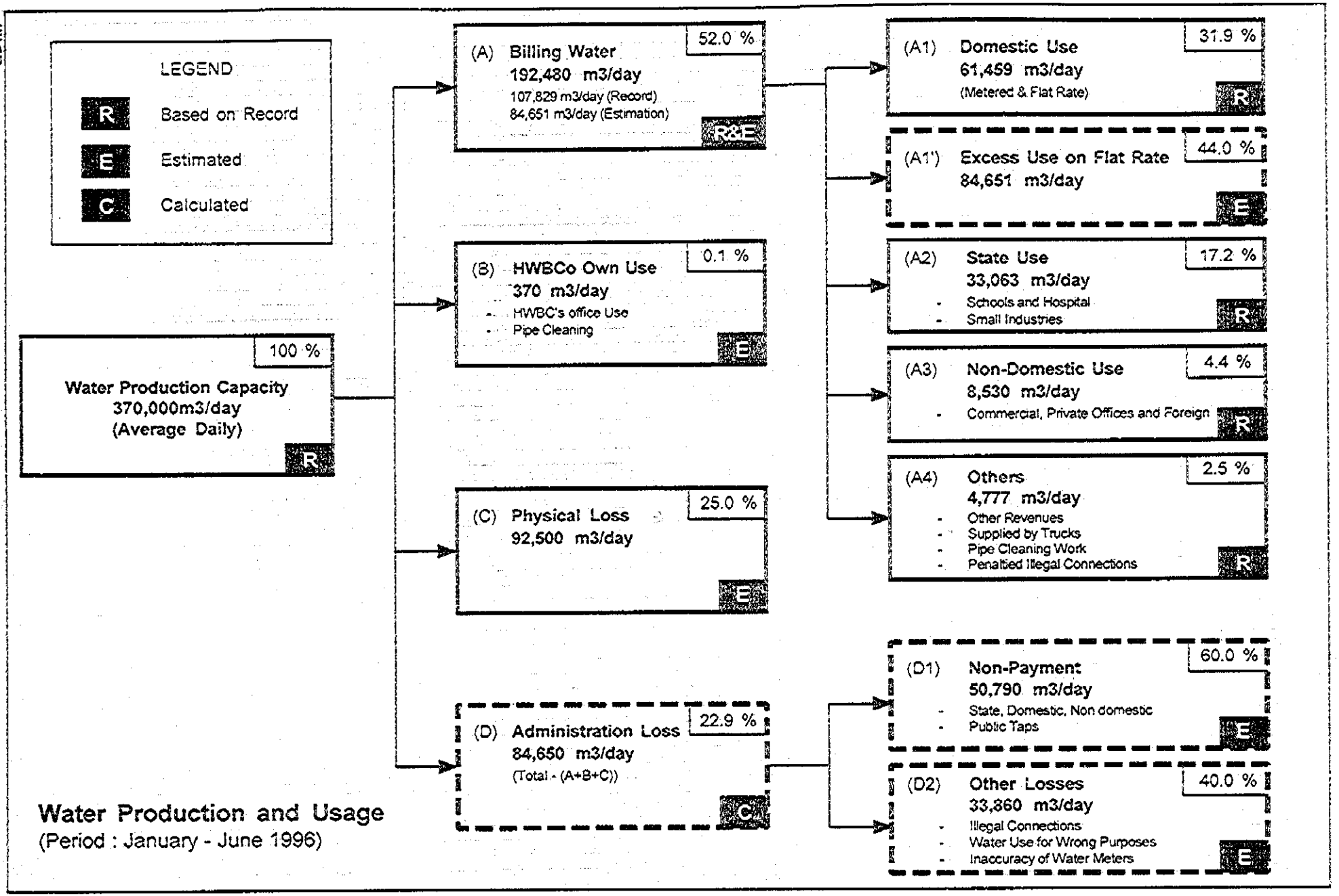
That is :
(d) Physical loss = 370,000 m3/d x 25% = 92,500 m3/d (25% of (a)).

Accordingly, Administrative loss is calculated as follows :
(e) Administrative loss = (Total loss) - (Physical loss)
= 177,100 - 92,500
= 84,600 m3/d (22.9% of (a)).

As regards the excessive use on flat rate, the customers are exempted from water charge for their excessive use over 4 m3/person/month owing to the present water tariff system. But essentially, the capacity of these excessive use should be charged in conformity with their consumption.

In this study, the excessive use on flat rate is regarded to be included in administration loss. Consequently, the Administration loss including the excessive use on flat rate is :
(e') Administration loss = (e) + (excessive use on flat rate)
= 84,600 m3/d + 84,600 m3/d
= 169,200 m3/d (45.8% of (a)).

The above is schematically presented in the following page, and the monthly production by each treatment plant and the monthly billing records for the period of January-June 1996 are given in the subsequent page; and the production in the year 1995 is attached for reference.


LEGEND
R Based on Record
E Estimated
C Calculated
Water Production Capacity
370,000m3/day
(Average Daily)
100 %
R
(A) Billing Water
192,480 m3/day
107,829 m3/day (Record)
84,651 m3/day (Estimation)
52.0 %
R&E
(B) HWBCo Own Use
370 m3/day
- HWBC's office Use
- Pipe Cleaning
0.1 %
E
(C) Physical Loss
92,500 m3/day
25.0 %
E
(D) Administration Loss
84,650 m3/day
(Total - (A+B+C))
22.9 %
C
(A1) Domestic Use
61,459 m3/day
(Metered & Flat Rate)
31.9 %
R
(A1') Excess Use on Flat Rate
84,651 m3/day
44.0 %
E
(A2) State Use
33,063 m3/day
- Schools and Hospital
- Small Industries
17.2 %
R
(A3) Non-Domestic Use
8,530 m3/day
- Commercial, Private Offices and Foreign
4.4 %
R
(A4) Others
4,777 m3/day
- Other Revenues
- Supplied by Trucks
- Pipe Cleaning Work
- Penalties Illegal Connections
2.5 %
R
(D1) Non-Payment
50,790 m3/day
- State, Domestic, Non domestic
- Public Taps
60.0 %
E
(D2) Other Losses
33,860 m3/day
- Illegal Connections
- Water Use for Wrong Purposes
- Inaccuracy of Water Meters
40.0 %
E
Water Production and Usage
(Period : January - June 1996)

MONTHLY TOTAL PRODUCTION

(YEAR: 1996, HWBCo)

(Unit: m3)

	No.	Month	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUNE	Total 1 - 6	Monthly Average	Daily Average
MAJOR PLANTS	1	Luong Yen	2,083,520	1,895,400	1,994,250	1,979,200	2,138,660	2,038,750	12,129,780	2,021,630	66,647
	2	Yen Phu	1,256,700	1,229,850	1,236,320	1,313,630	1,247,810	1,325,740	7,610,050	1,268,342	41,813
	3	Ngo Si Lien	1,130,270	1,280,920	1,182,200	1,248,940	1,274,260	1,163,540	7,280,130	1,213,355	40,001
	4	Tuong Mai	839,960	803,290	777,730	977,550	839,220	787,740	5,025,490	837,582	27,613
	5	Mai Dich	1,954,270	1,779,080	1,814,730	1,786,775	1,983,010	1,683,206	11,001,071	1,833,512	60,445
	6	Phap Van	715,460	672,850	641,600	651,450	632,490	615,960	3,929,810	651,968	21,592
		Ngoc Ha 2	1,048,602	956,502	964,249	976,547	1,059,790	935,795	5,941,485	990,248	32,646
		Ngoc Ha 1	409,200	403,960	432,250	419,270	431,960	368,650	2,465,290	410,882	13,546
	8	Ha Dinh	710,525	724,280	827,980	843,860	891,530	816,050	4,814,225	802,371	26,452
	Sub Total (1-8)		10,148,507	9,746,132	9,871,309	10,197,222	10,498,730	9,735,431	60,197,331	10,032,889	330,755
MINOR PLANTS	9	Don Thuy	231,500	217,500	290,780	292,880	289,760	306,880	1,629,300	271,550	8,952
	10	Van Don	77,228	74,479	69,637	63,337	68,371	75,083	428,135	71,356	2,352
	11	Thuy Loi	64,117	66,768	61,202	72,825	63,948	71,140	400,000	66,667	2,198
	12	Bach Khoa	41,879	44,173	41,853	48,259	40,530	46,823	263,517	43,920	1,448
	13	Quynh Mai	90,071	64,668	77,399	95,148	90,708	83,063	501,057	83,510	2,753
	14	Bach Mai	68,702	57,598	59,687	71,423	77,032	77,449	414,891	69,149	2,280
	15	KH/Trung	17,168	19,228	17,997	18,766	20,491	20,006	113,656	18,943	624
	16	Kim Giang	26,552	30,241	28,385	31,699	36,460	40,870	194,207	32,368	1,067
	17	Giap Bat	18,320	22,980	19,700	21,300	22,200	22,600	127,100	21,183	698
	18	Gia Lam	111,738	129,520	118,620	129,500	131,156	130,241	750,775	125,129	4,125
	19	Dong Anh	61,500	66,900	62,600	64,300	66,300	71,400	393,000	65,500	2,159
	20	Sai Dong	26,216	25,777	19,747	27,190	29,571	27,789	156,290	26,048	859
	21	Thuy Khue	140,385	119,782	128,511	128,101	135,100	122,066	773,945	128,991	4,252
	22	Phuc tan	76,940	112,740	19,210	65,020	76,830	77,300	428,040	71,340	2,352
	23	An Duong	94,117	107,323	84,610	85,233	92,750	100,695	564,728	94,121	3,103
	Sub Total (9-23)		1,146,433	1,159,677	1,099,938	1,217,981	1,241,207	1,273,405	7,138,641	1,189,774	39,223
Total (1-23)			11,294,940	10,905,809	10,971,247	11,415,203	11,739,937	11,008,836	67,335,972	11,222,662	369,982

370,000 m3/d

MONTHLY BILLING RECORDS

(YEAR: 1996, HWBCo)

(Unit: m3)

MONTH / CATEGORY	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	Total (1-6)	Daily Average
A1 Domestic	1,810,225	1,734,362	1,830,326	1,905,449	1,892,991	2,012,215	11,185,568	61,459
A2 State	1,046,216	999,572	912,555	974,328	1,010,256	1,074,596	6,017,523	33,063
A3 Non-Domestic	247,956	252,900	234,051	264,952	268,315	284,275	1,552,449	8,530
A4 Other Revenues	126,814	52,117	118,983	169,237	212,961	157,538	837,650	4,602
Supplied by Trucks	1,470	955	885	1,145	1,734	1,910	8,099	45
Pipe Cleaning	9,636	908		3,225	340	2,726	16,835	93
Penaltied Illegal Connections	1,404	396	1,260	1,494	1,620	612	6,786	37
Sub Total (A4)	139,324	54,376	121,128	175,101	216,655	162,786	869,370	4,777
Total	3,243,721	3,041,210	3,098,060	3,319,830	3,388,217	3,533,872	19,624,910	107,829

TOTAL MONTHLY PRODUCTION

(Year : 1995. HWBCo)

(Unit: m³)

	No	Month	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	7 JUL	8 AUG	9 SEP	10 OCT	11 NOV	12 DEC	Total (1 - 12)	Monthly Average	Daily Average
MAJOR PLANTS	1	Luong Yen	1,636,360	1,984,260	1,866,640	1,796,880	1,989,510	2,030,270	2,090,720	2,237,280	2,085,280	2,150,840	1,990,030	1,895,210	23,793,280	1,982,773	66,092
	2	Yen Phu	1,047,620	1,137,170	1,090,490	1,208,610	1,247,310	1,189,690	1,301,260	1,422,520	1,373,010	1,317,310	1,255,770	1,164,680	14,755,440	1,229,620	40,987
	3	Ngo Si Lien	1,124,880	1,175,840	1,129,950	1,195,490	1,215,640	1,153,180	1,229,350	1,231,940	1,274,640	1,219,700	1,131,620	1,250,850	14,331,080	1,194,257	39,809
	4	Tuong Mai	742,360	848,260	797,360	799,040	824,660	803,460	835,660	799,160	828,140	828,580	808,560	789,570	9,705,310	808,776	26,959
	5	Mai Dich	1,640,790	1,879,910	1,710,140	1,761,420	1,822,472	1,718,690	1,761,170	1,904,170	1,833,780	1,768,350	1,759,530	1,728,450	21,288,872	1,774,073	59,136
	6	Phap Van	724,540	843,830	767,740	735,410	788,220	734,820	775,890	780,590	779,090	755,510	740,510	727,130	9,153,280	762,773	25,426
	7	Ngoc Ha 2	900,740	983,390	907,780	953,050	986,990	953,070	966,330	922,540	965,810	1,052,550	1,013,920	952,784	11,558,954	963,246	32,108
		Ngoc Ha 1	453,800	416,600	463,750	415,400	429,920	410,550	424,700	429,920	412,130	423,210	417,960	430,200	5,128,140	427,345	14,245
	8	Ha Dinh	762,400	700,000	773,200	748,780	753,100	750,000	763,550	765,650	733,400	769,800	750,000	714,280	8,984,160	748,680	24,956
	Sub Total (1-8)		9,053,490	9,967,260	9,507,550	9,614,080	10,057,822	9,763,730	10,148,630	10,493,770	10,285,280	10,285,850	9,867,900	9,653,154	118,698,516	9,891,543	329,718
MINOR PLANTS	9	Don Thuy	212,400	189,000	217,000	210,000	217,000	210,000	217,000	217,000	207,400	232,500	225,000	222,040	2,576,340	214,695	7,157
	10	Van Don	58,700	55,170	61,340	59,170	56,000	54,230	60,300	59,400	57,600	113,980	115,249	79,677	831,016	69,251	2,308
	11	Thuy Loi	74,400	65,000	63,600	68,300	64,800	56,360	71,510	71,510	70,750	72,440	72,900	79,733	831,303	69,275	2,309
	12	Bach Khoa	55,636	51,408	56,916	56,732	58,623	56,732	51,503	44,910	44,982	46,190	30,360	35,194	589,186	49,099	1,637
	13	Quynh Mai	48,360	43,680	48,360	44,064	45,523	44,064	45,532	45,532	82,620	87,730	82,515	81,940	699,920	58,327	1,944
	14	Bach Mai	48,391	43,708	47,286	62,424	64,244	56,724	64,504	82,940	76,903	80,019	65,384	51,190	743,717	61,976	2,066
	15	KH/Trung	17,081	15,428	17,081	24,786	25,612	24,786	25,306	25,612	17,556	18,445	16,114	15,993	243,800	20,317	677
	16	Kim Giang	50,592	46,256	47,908	38,006	39,841	38,556	39,841	39,000	38,556	40,300	39,000	30,619	488,275	40,690	1,356
	17	Giap Bat	11,129	10,052	11,129	16,156	16,695	14,056	16,695	16,695	16,156	16,364	16,322	18,970	180,919	15,077	503
	18	Gia Lam	179,292	161,988	179,292	167,995	173,165	152,294	148,654	122,295	107,450	110,162	97,087	123,982	1,723,656	143,638	4,788
	19	Dong Anh	87,981	81,363	95,334	90,882	93,911	73,900	86,161	63,300	62,100	61,100	59,500	56,300	911,837	75,986	2,533
	20	Sai Dong	37,944	33,742	36,230	36,720	37,576	35,280	35,053	29,512	30,710	24,980	22,549	18,031	378,327	31,527	1,051
	21	Thuy Khue	136,860	136,860	136,860	136,860	136,860	136,860	136,860	136,860	136,860	136,860	142,045	131,676	1,610,581	136,860	4,562
	22	An Duong	-	-	-	-	-	-	-	90,051	101,160	133,920	74,917	90,051	490,099	98,020	3,267
	Sub Total (9-22)		1,018,566	933,660	1,018,336	1,012,095	1,029,850	953,842	999,119	1,044,617	1,050,803	1,175,490	1,058,942	1,035,396	12,330,716	1,027,560	34,252
Total (1-22)			10,072,056	10,900,920	10,525,886	10,626,175	11,087,672	10,717,572	11,147,749	11,538,387	11,336,083	11,461,340	10,926,842	10,688,550	131,029,232	10,919,103	363,970

2.5.2 Treatment Plants

<Production>

There are eight (8) major treatment plants in the urban center of Hanoi, all operated by HWBC. The production capacity of these major plants is 67,000-22,000 m3/day, averaging 41,000 m3/day. In addition to the major plants, there are also 15 small plants operated by HWBC, as of June 1996. The capacity of the small plants is in the range of 9,000-600 m3/day. The total production capacity from the above 8 major and 15 small plants is 370,000 m3/day on the average, for the period of January-June 1996.

Monthly Production of HWBC's Treatment Plants
(Year : 1996)

(Unit : m3)

	No	Month	1 JAN	2 FEB	3 MAR	4 APR	5 MAY	6 JUN	Total 1-6	Monthly Average	Daily Average
Major Plants	1	Luong Yen	2,083,520	1,895,400	1,994,250	1,979,200	2,138,660	2,038,750	12,129,780	2,021,630	66,647
	2	Yen Phu	1,256,700	1,229,850	1,236,320	1,313,630	1,247,810	1,325,740	7,610,050	1,268,342	41,813
	3	Ngo Si Lien	1,130,270	1,280,920	1,182,200	1,248,940	1,274,260	1,163,540	7,280,130	1,213,355	40,001
	4	Truong Mai	839,960	803,290	777,730	977,550	839,220	787,740	5,025,490	837,582	27,613
	5	Mai Dich	1,954,270	1,779,080	1,814,730	1,785,775	1,983,010	1,683,206	11,001,071	1,833,512	60,445
	6	Phap Van	715,460	672,850	641,600	651,450	632,490	615,960	3,929,810	654,968	21,592
	7	Ngoc Ha 2	1,048,602	956,502	964,249	976,547	1,059,790	935,795	5,941,485	990,248	32,646
		Ngoc Ha 1	409,200	403,960	432,250	419,270	431,960	369,650	2,465,290	410,882	13,546
	8	Ha Dinh	710,525	724,280	827,980	843,860	891,530	816,050	4,814,225	802,371	26,452
	Sub Total (1-8)		10,148,507	9,746,132	9,871,309	10,197,222	10,498,730	9,735,431	60,197,331	10,032,889	330,755
Small Plants	9	Don Thuy	231,500	217,500	290,780	292,680	289,760	306,680	1,629,300	271,550	8,952
	10	Van Don	77,228	74,479	69,637	63,337	68,371	75,083	428,135	71,356	2,352
	11	Thuy Loi	64,117	66,768	61,202	72,825	63,948	71,140	400,000	66,667	2,198
	12	Bach Khoa	41,879	44,173	41,853	48,259	40,530	46,823	263,517	43,920	1,448
	13	Quynh Mai	90,071	64,668	77,399	95,148	90,708	83,063	501,057	83,510	2,753
	14	Back Mai	68,702	57,598	59,687	74,423	77,032	77,449	414,891	69,149	2,280
	15	KH/Trung	17,168	19,228	17,997	18,766	20,491	20,006	113,656	18,943	624
	16	Kim Giang	26,552	30,241	28,385	31,699	36,460	40,870	194,207	32,368	1,067
	17	Giap Bat	18,320	22,980	19,700	21,300	22,200	22,600	127,100	21,183	698
	18	Gia Lam	111,738	129,520	118,620	129,500	131,156	130,241	750,775	125,129	4,125
	19	Dong Anh	61,500	66,900	62,600	64,300	68,300	71,400	393,000	65,500	2,159
	20	Sai Dong	26,216	25,777	19,747	27,190	29,571	27,789	156,290	26,048	859
	21	Thuy Khue	140,385	119,782	128,511	128,101	135,100	122,066	773,945	128,991	4,252
	22	Phuc Tan	76,940	112,740	19,210	65,020	76,830	77,300	428,040	71,340	2,352
	23	An Duong	94,117	107,323	84,610	85,233	92,750	100,695	564,728	94,121	3,103
	Sub Total (9-23)		1,146,433	1,159,677	1,099,938	1,217,981	1,241,207	1,273,405	7,138,641	1,189,774	39,223
Total (1-23)			11,294,940	10,905,809	10,971,247	11,415,203	11,739,937	11,008,836	67,335,972	11,222,662	369,978

Note 1 :

In addition to the above, there exist 241 private organizations (mainly factories and enterprises) which take groundwater of 129,000 m3/day with 300 deep wells, for their own use. This fact is important for planning of future water demand and for evaluation of the maximum available groundwater source in the city area.

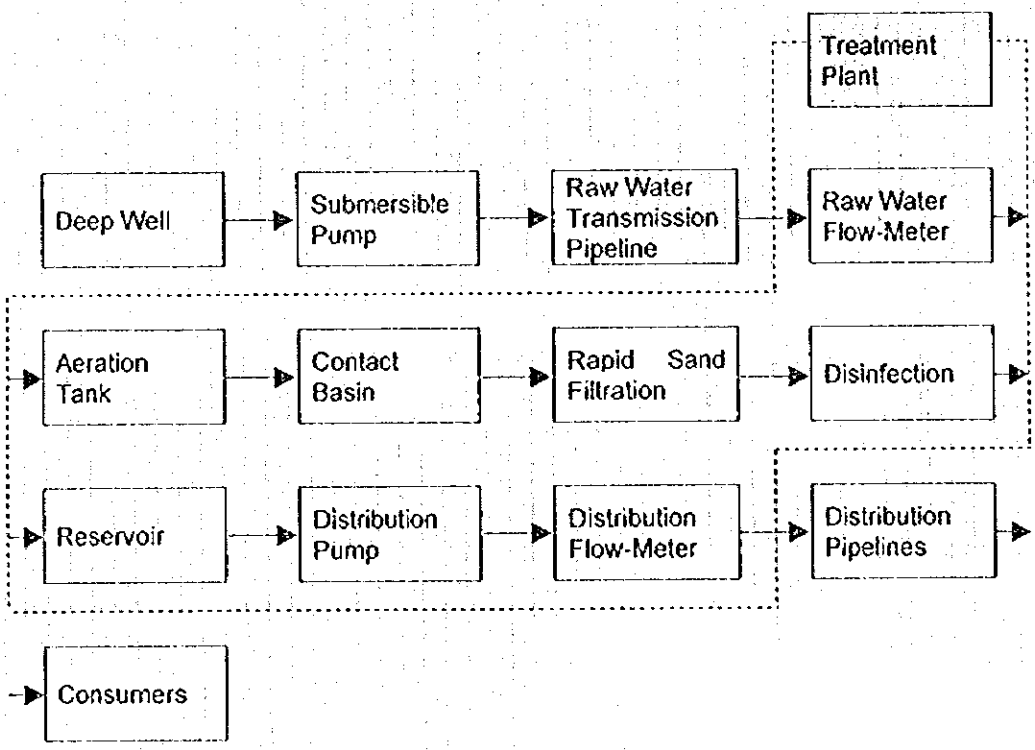
Note 2 :

Furthermore, in some areas of Thanh Tri and Tu Liem, there are four (4) small-scaled public water supply systems which are located on the outside of HWBC's present territory, and are administrated and operated by people's committees in those communities. The present conditions in this chapter, however, deals with HWBC's treatment plants, excluding such small systems which are not administrated by HWBC, for the sake of convenience.

<Treatment Process>

The main objectives of the treatment are removal of iron and manganese predominantly contained in the groundwater source in Hanoi area, and disinfection to the filtrated water.

The treatment is done with a basic treatment process for groundwater containing iron and manganese. The typical treatment process employed commonly in all the plants is shown below :



Facilities in the treatment plant, starting from a raw water flow meter/s and ending with a distribution flow meter/s, are briefly described below.

Raw Water Flow Meter

At the entrance of the plant, total raw water flow is measured with an electromagnetic flow meter/s installed on the inlet pipeline (raw water main) to aeration tanks. The flow is observed and recorded at the central control room in the administration building. (Small plants, however, are not equipped with flow meters for raw water).

Aeration

Aeration is performed by a way of spraying water through perforated pipes onto a multi-layered concrete floor with small holes. Each block of 30,000 m3/d capacity has 6 separation units, with an aeration area of 216 m^2 in total. The height of one aeration unit is 2.5 m, including one intermediate hollow floor. The aeration rate used for dimensioning the facilities is 5.8- 6.7 $m3/m^2/h$.

Contact Basin

The contact basins in the plants are constructed totally or partly underneath the aeration towers. In the basin, oxidized iron is flocculated and some precipitation occurs. In the plants where higher concentration of iron is in the raw water, longer detention time in the contact basin has been provided.

Filtration

Water preliminarily treated through aeration tanks and contact basins is finally treated by rapid sand filters through the process of filtration.

A unit of 30,000 m3/d plants has 6 parallel rapid sand filters with a total area of 252 m^2, employing a filtration rate of 120 m/d. The filters have combined air-water back washing system, through the filter bottom, which is equipped with plastic nozzles. The thickness of the filter beds is 1.5 m, including the supporting layer of 0.15 m, where the grain size is 2.3 - 4.0 mm. The size of the

filter sands is 0.9 - 1.6 mm. The design filtration rate is 5 m3/m^2/h, regulated with a hydraulic valve in the outlet side. The filter backwashing is carried out firstly by air-water and secondarily by sole water. All the main process valves for the backwashing are electrically controlled. The back wash water recovery system has been constructed at some plants; but it has not been used due to operational problems.

Disinfection

Disinfection is carried out by using liquid chlorine. Chlorine is dosed into the filtered water pipeline before it enters the reservoirs. In small treatment plants, on the other hand, the disinfection is done by using liquid hypo-chlorite and it is dosed at the entrance of reservoirs.

Reservoir

Reservoirs which store the treated water are located in the yard of the treatment plants. They are made of reinforced concrete and placed on half-ground levels. (High water levels of the reservoir are set at about 1 m over the land surface of the plants.) The volume of the reservoirs is 20%-volume of the daily production capacity, which is equivalent to 4.8 hours' volume.

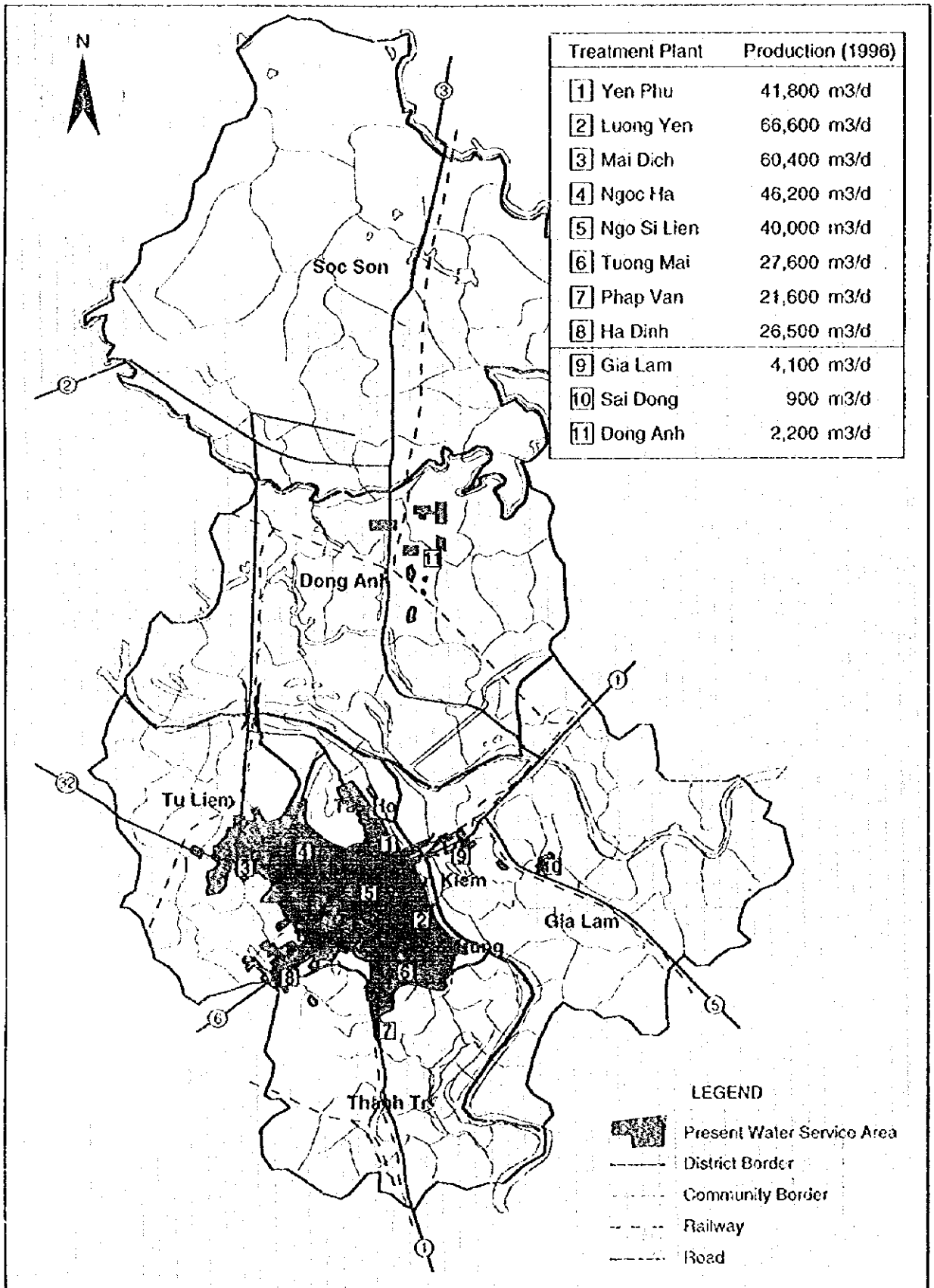
Distribution Pump

The treated water is distributed to consumers by distribution pumps (direct-pumping distribution system) which are installed nearby the reservoirs. The pumping head (pressure) is 40 - 45 m to new pipeline networks, and 15 - 25 m to old networks.

(Note)
There exist several elevated tanks in the treatment plants and in the distribution networks, but none of them is in use at present. The reasons for not using the elevated tanks are the low pressure in the network mainly, and the poor condition of the tank structures partly.

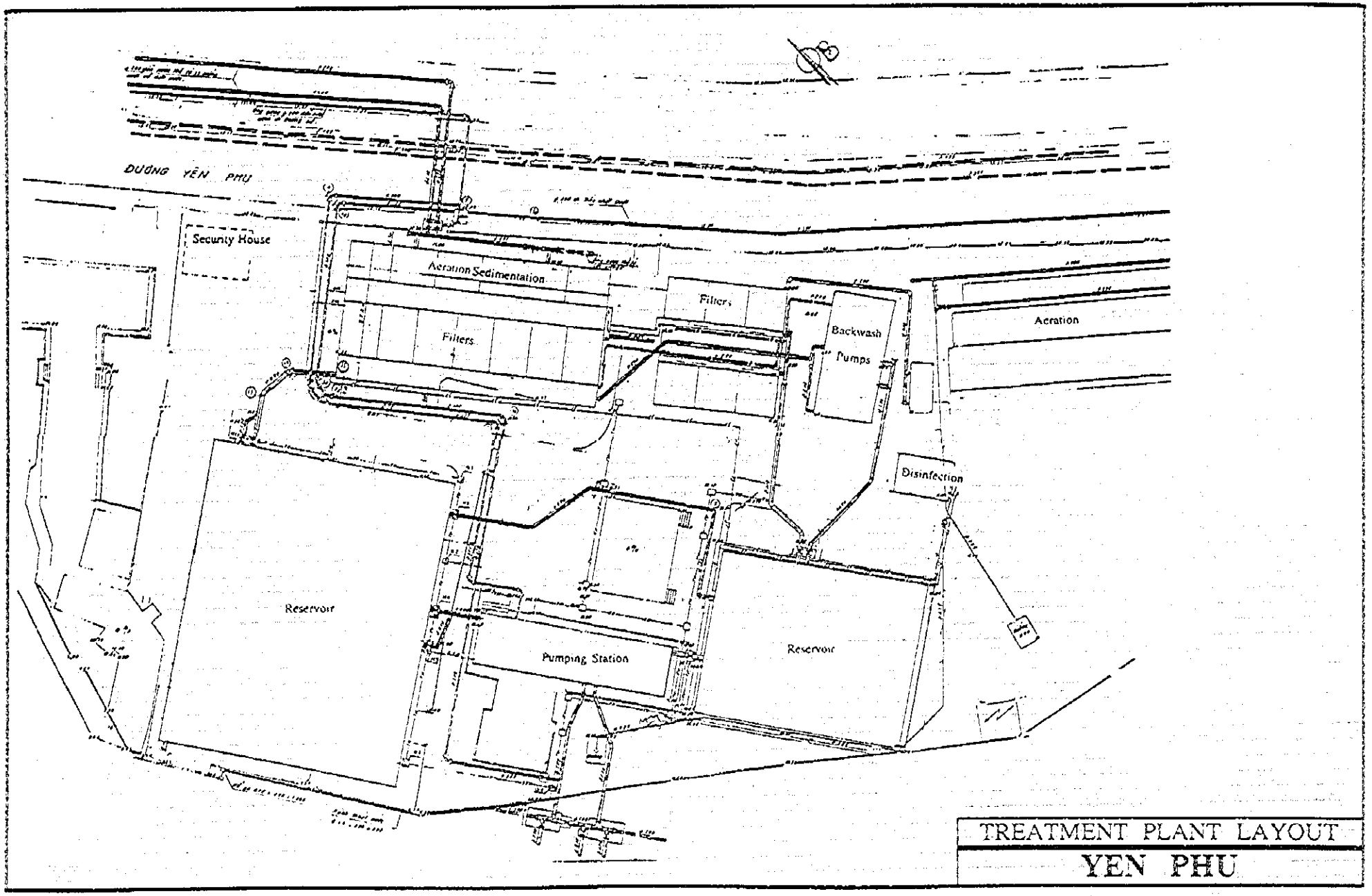
Distribution Flow Meter

The distributed water is measured with electromagnetic flow meters installed on distribution mains in the plants. The flow is observed and recorded at the central control room in the administration building, together with the raw water flow. (In the small treatment plants, on the other hand, the flow meter is of wheel-type. By the early 1996, all the small plants have been equipped with distribution flow meters for proper operation.)



Treatment Plant	Production (1996)
[1] Yen Phu	41,800 m3/d
[2] Luong Yen	66,600 m3/d
[3] Mai Dich	60,400 m3/d
[4] Ngoc Ha	46,200 m3/d
[5] Ngo Si Lien	40,000 m3/d
[6] Tuong Mai	27,600 m3/d
[7] Phap Van	21,600 m3/d
[8] Ha Dinh	26,500 m3/d
[9] Gia Lam	4,100 m3/d
[10] Sai Dong	900 m3/d
[11] Dong Anh	2,200 m3/d

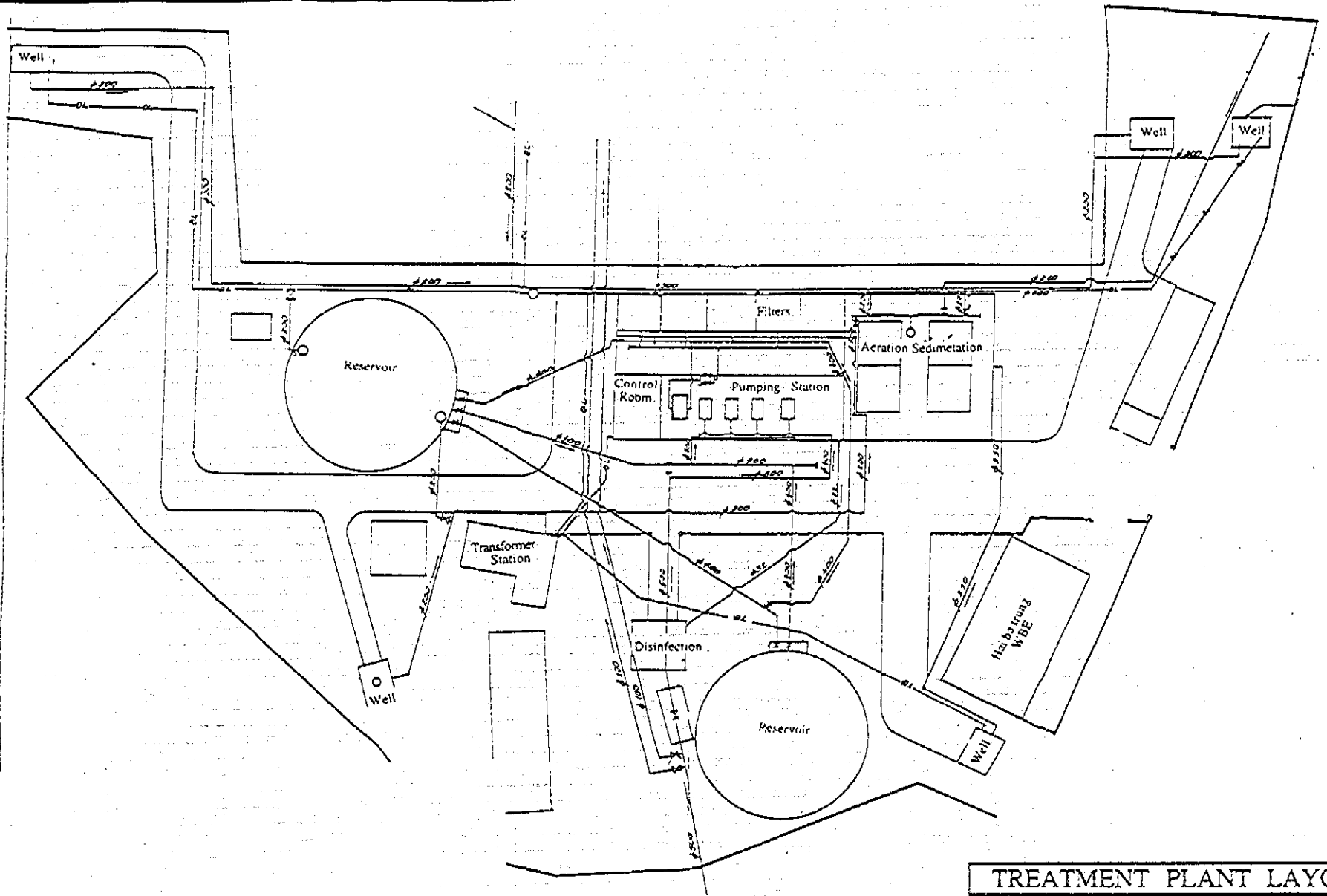
Location of HWBC's Treatment Plants



TREATMENT PLANT LAYOUT

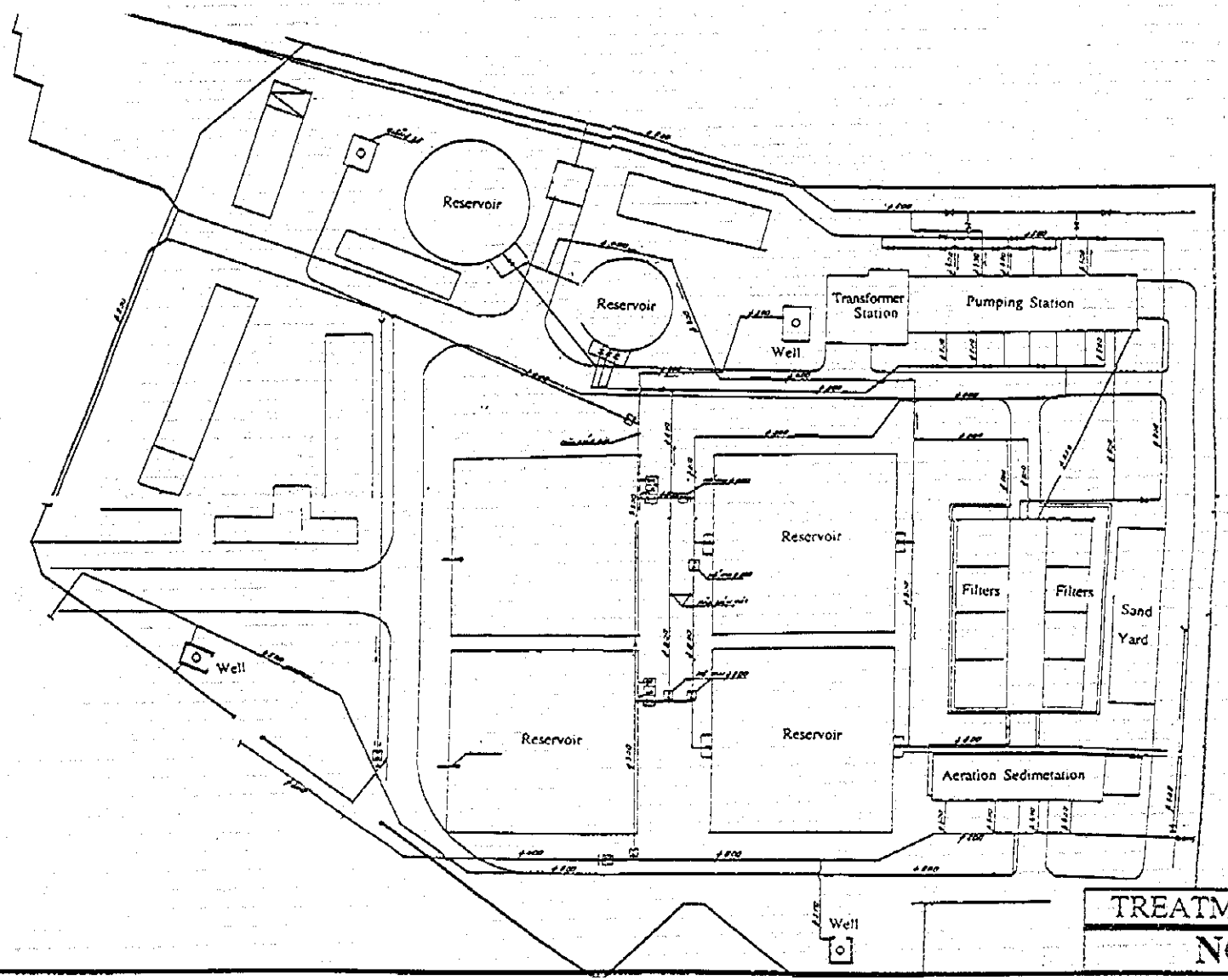
YEN PHU

A-2-81



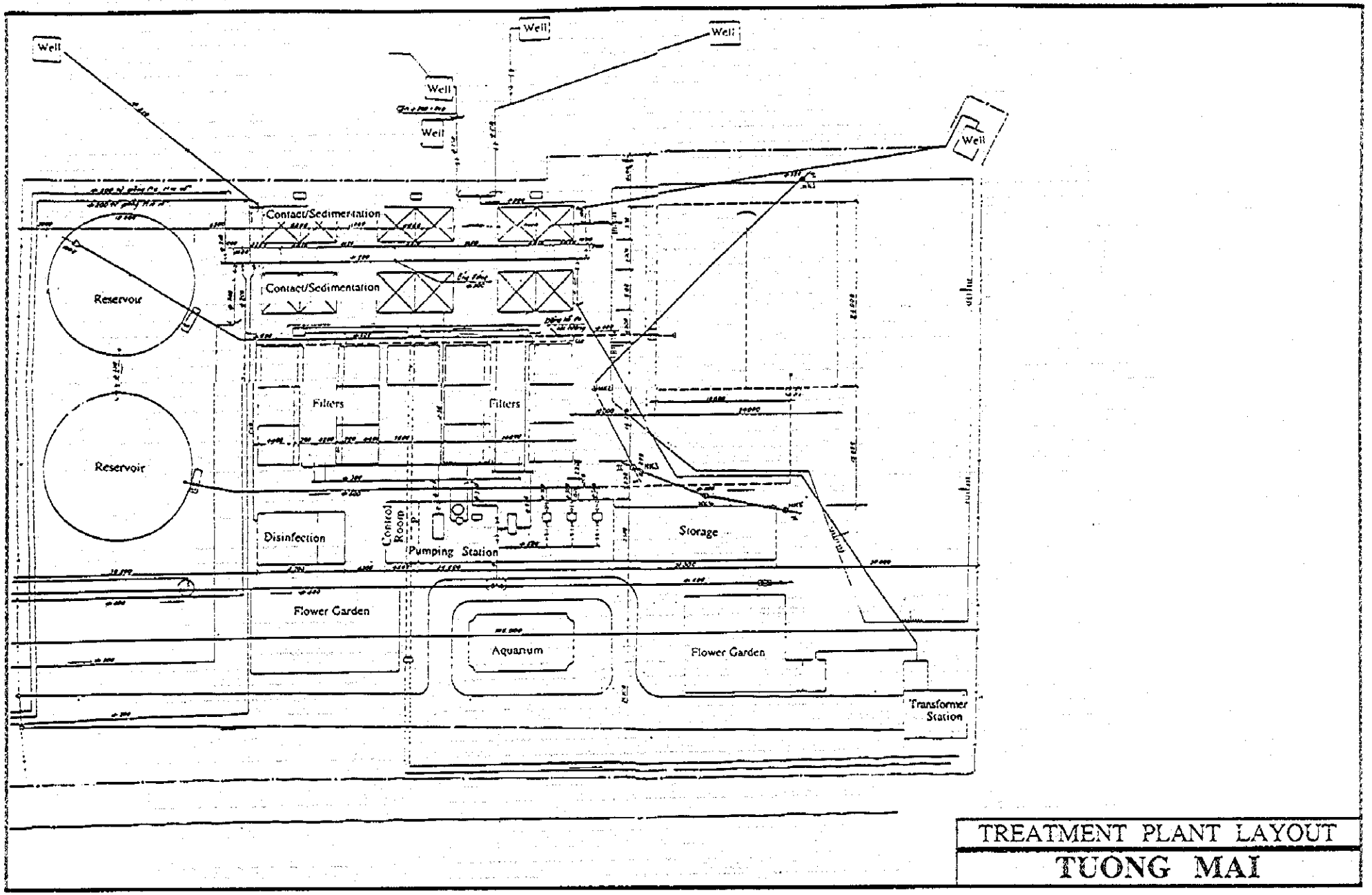
TREATMENT PLANT LAYOUT

LUONG YEN



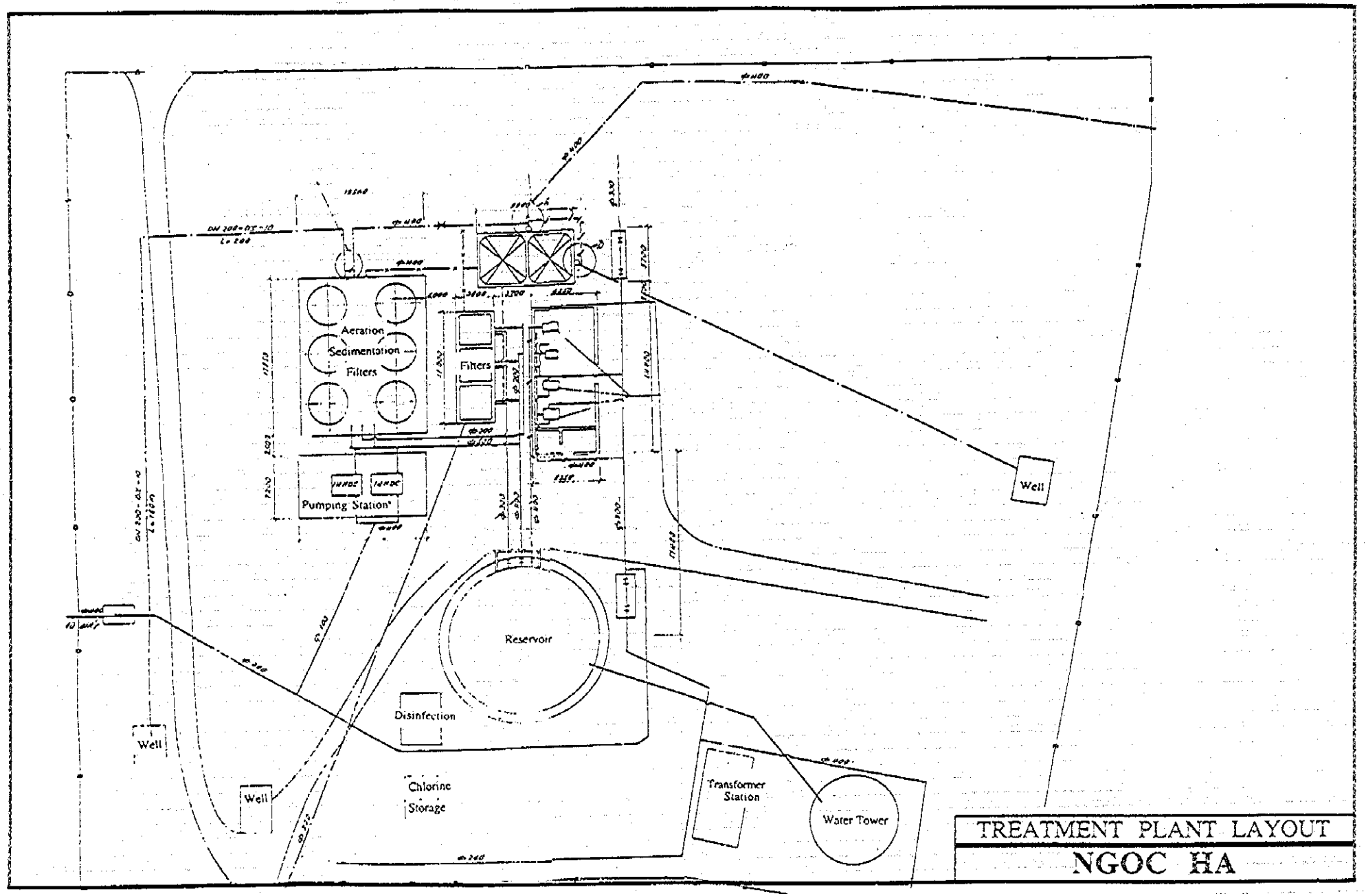
TREATMENT PLANT LAYOUT

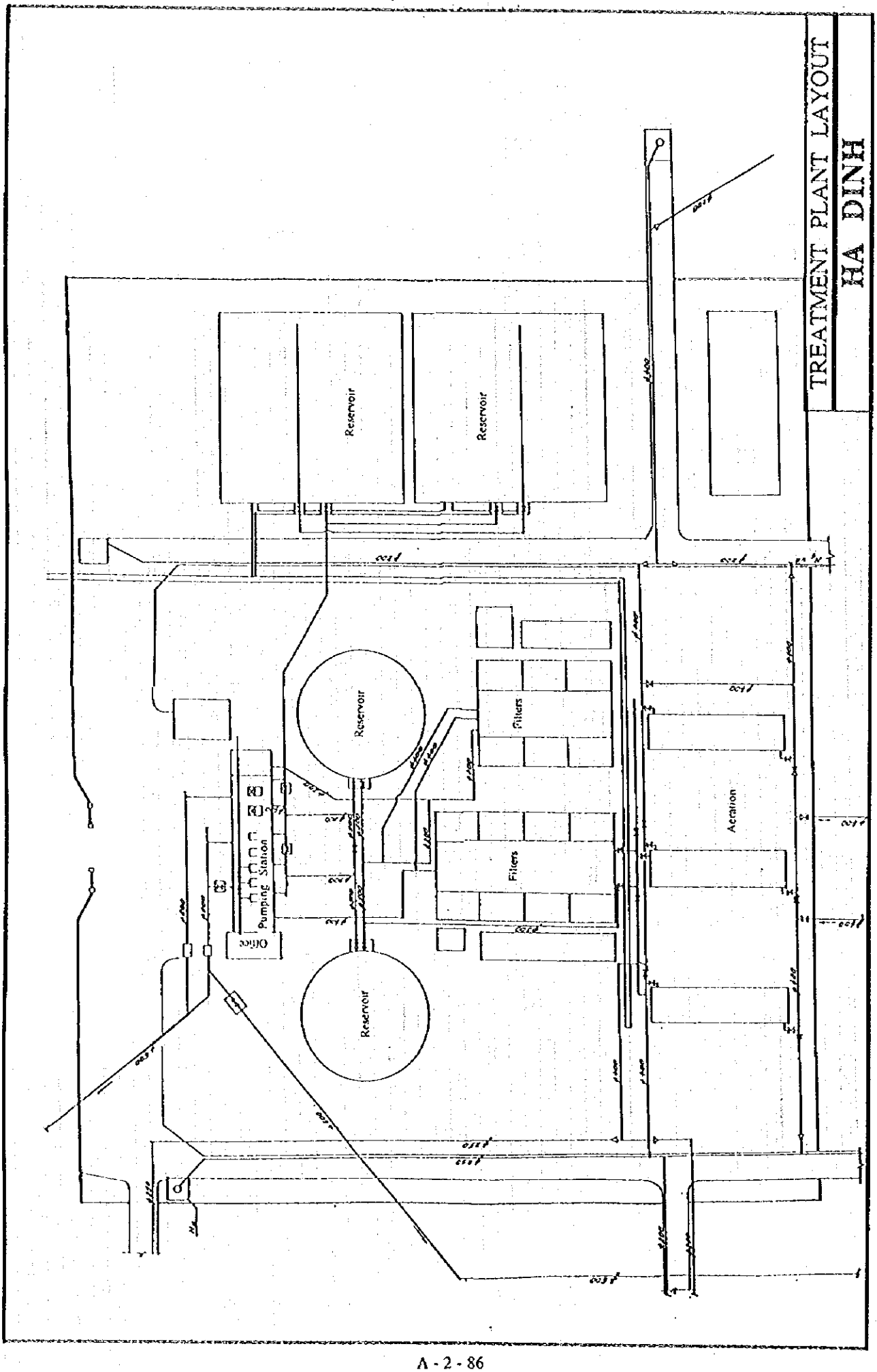
NGO SI LIEN

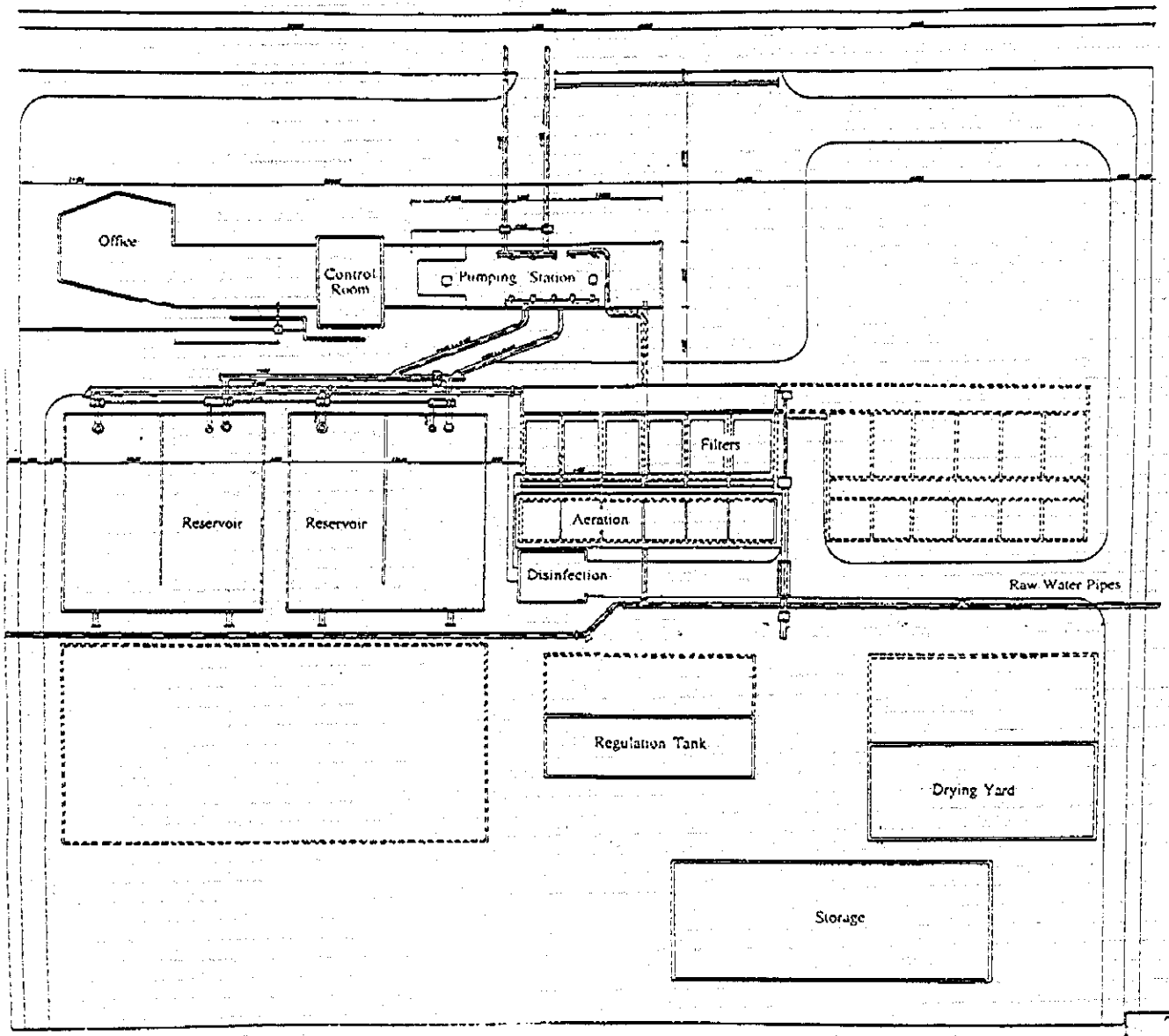


TREATMENT PLANT LAYOUT

TUONG MAI

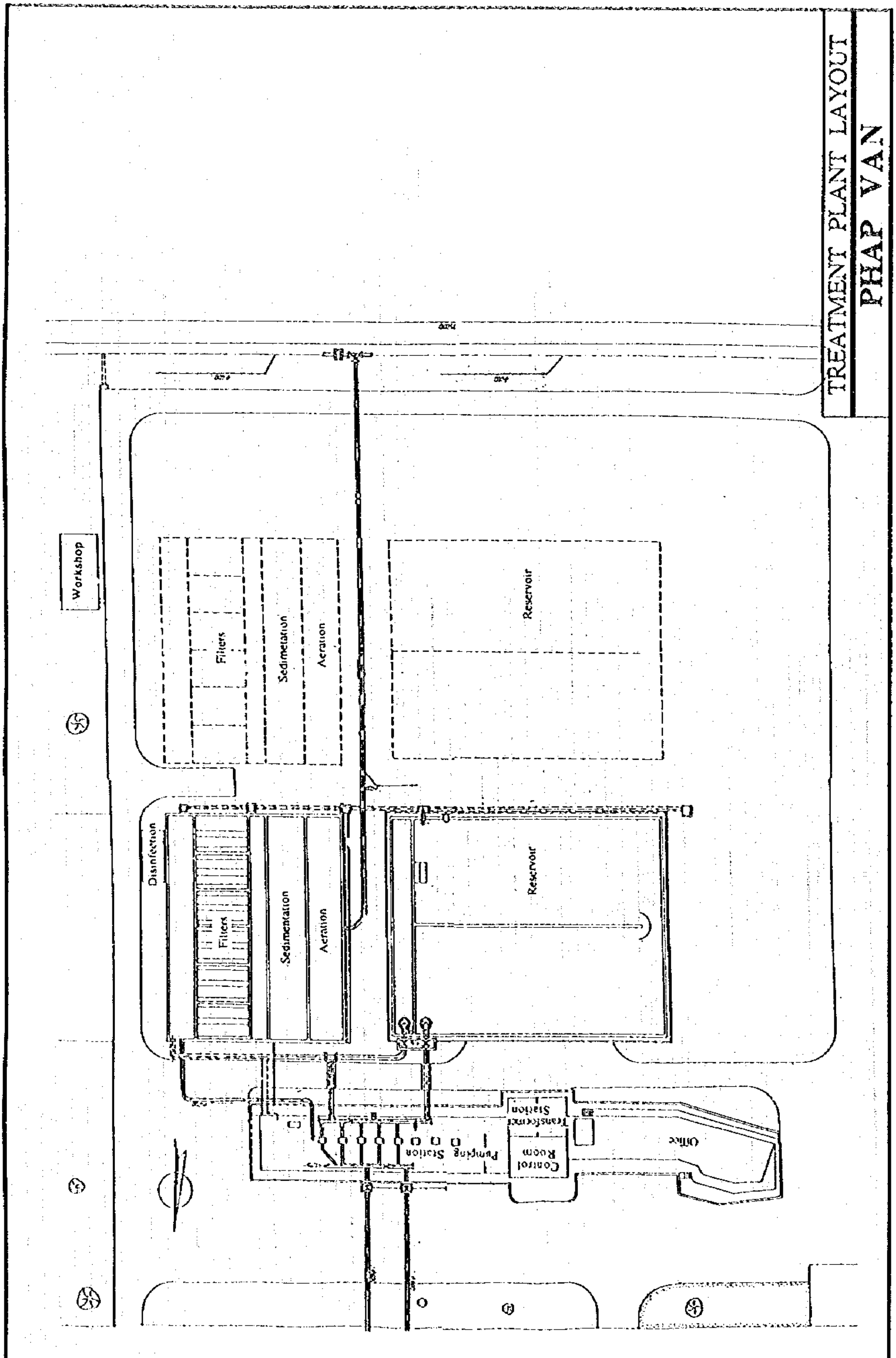

Aeration
Sedimentation
Filters
Filters
Pumping Station
Well
Reservoir
Disinfection
Well
Well
Chlorine
Storage
Transformer
Station
Water Tower
TREATMENT PLANT LAYOUT
NGOC HA

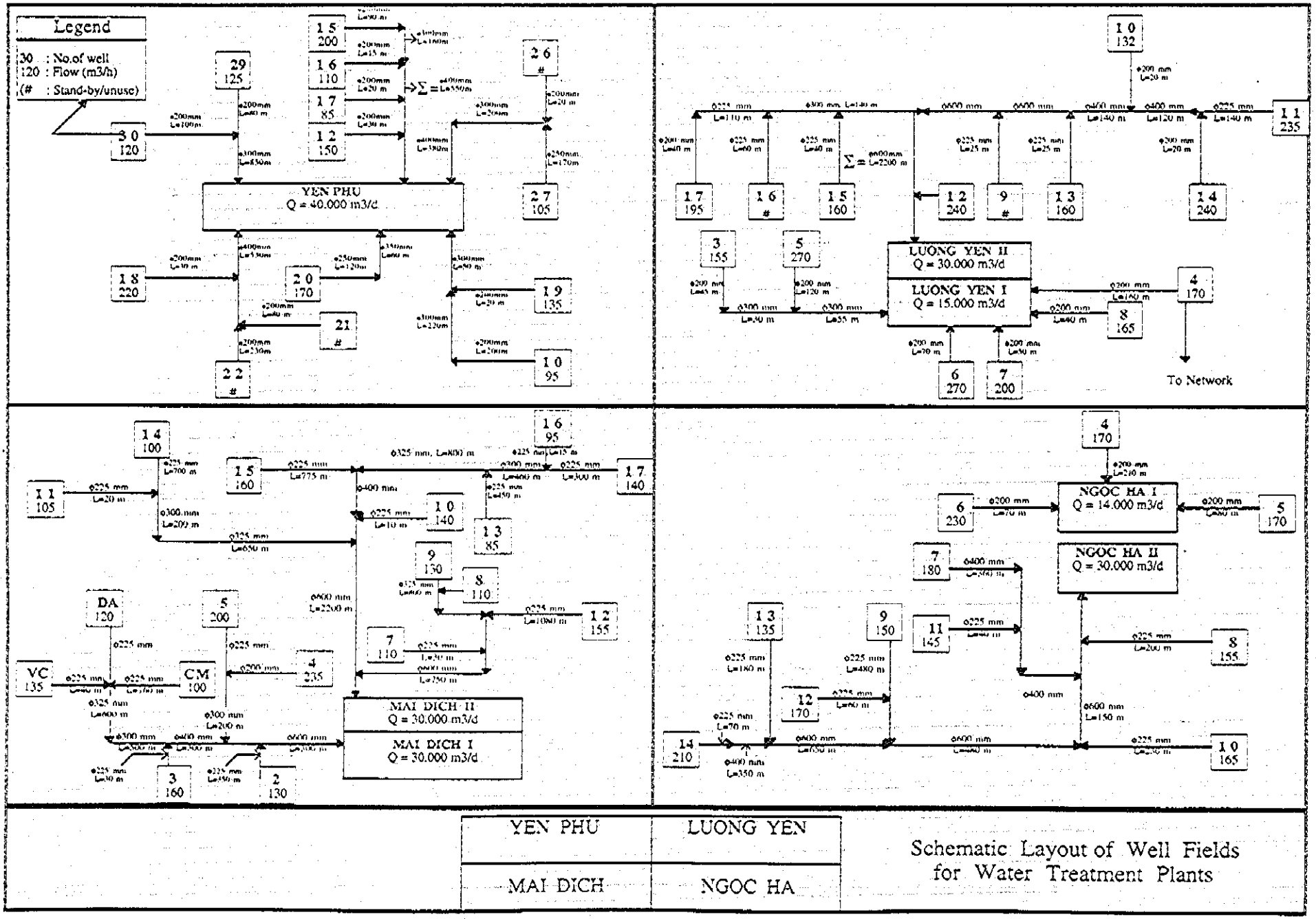

TREATMENT PLANT LAYOUT
HA DINH
Reservoir
Reservoir
Reservoir
Reservoir
Filters
Filters
Aeration
Pumping Station
Office

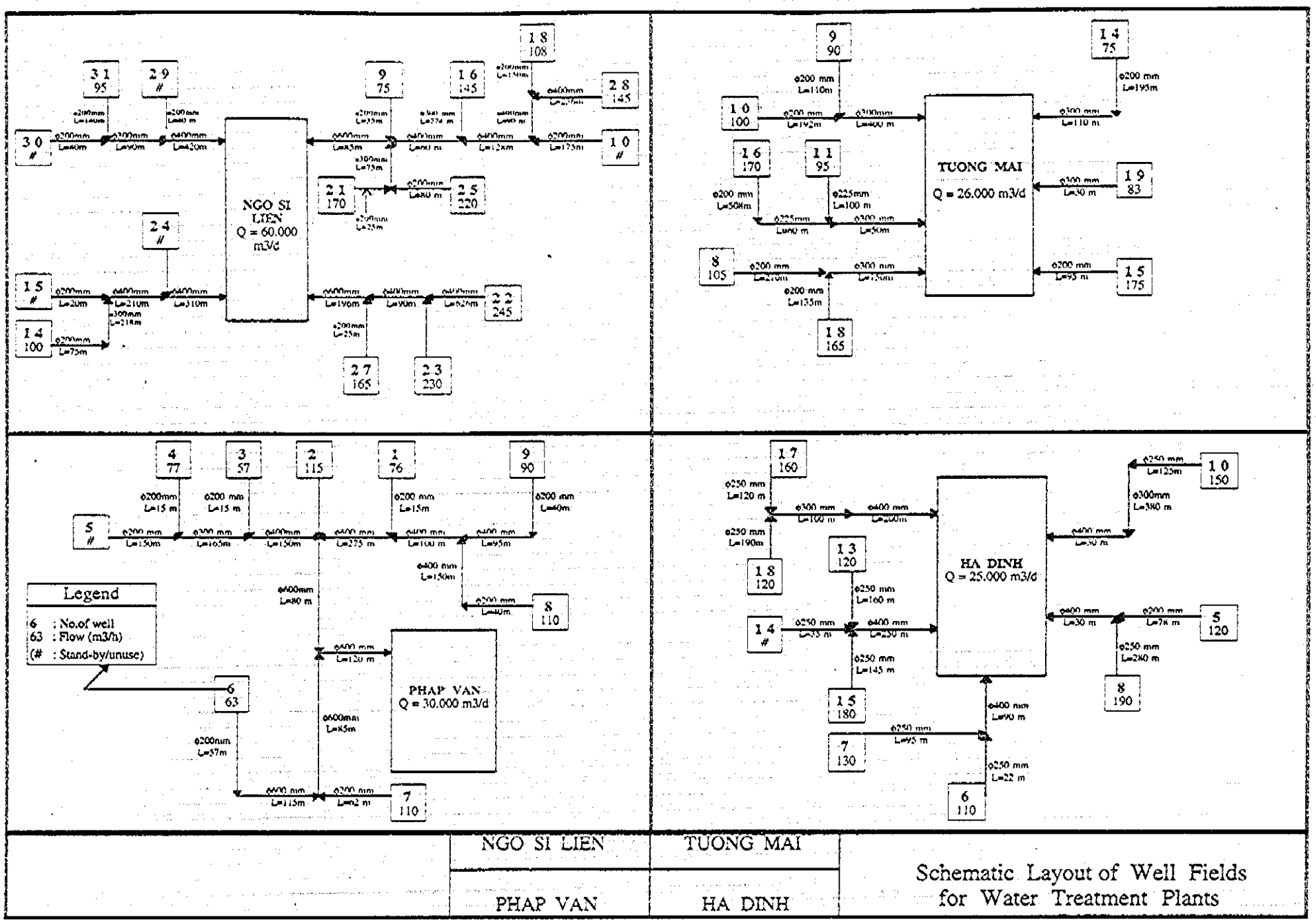


TREATMENT PLANT LAYOUT

MAI DICH.


TREATMENT PLANT LAYOUT
PHAP VAN
Workshop
Filters
Sedimentation
Aeration
Reservoir
Disinfection
Filters
Sedimentation
Aeration
Reservoir
Pumping Station
Control Room
Transformer Station
Office


Legend
30 : No.of well
120 : Flow (m3/h)
(# : Stand-by/unuse)
YEN PHU
Q = 40.000 m3/d
LUONG YEN II
Q = 30.000 m3/d
LUONG YEN I
Q = 15.000 m3/d
To Network
MAI DICH II
Q = 30.000 m3/d
MAI DICH I
Q = 30.000 m3/d
NGOC HA I
Q = 14.000 m3/d
NGOC HA II
Q = 30.000 m3/d
YEN PHU
LUONG YEN
MAI DICH
NGOC HA
Schematic Layout of Well Fields for Water Treatment Plants



	NGO SI LIEN	TUONG MAI	Schematic Layout of Well Fields for Water Treatment Plants
	PHAP VAN	HA DINH	

2.5.3 Intake Facilities

Intake facilities consist of deep wells, intake submersible pumps, pump houses and raw water pipelines going toward treatment plants.

Deep Wells and Intake Pumps

The present water source used for HWBC water supply system is groundwater existing beneath the city. There are 105 deep wells (about 60-70 m deep) located in the wellfields around 8 major treatment plants taking 365,800 m^3/d (as raw water) in the average.

Raw water taken from the wells is lifted by an intake submersible pump, in principle, which is placed in the well's tube.

In addition, there are 15 small plants which are operated by the enterprises under HWBC. These small plants have 36 wells taking about 40,000 m3/d.

Raw Water Pipelines

Raw water pumped by submersible pumps is transmitted to a treatment plant through a raw water pipeline. Most of the pipelines collect water from other wells on the way going to the plant, and some pipelines solely head toward the plant. The pipelines have diameters of 200 - 600 mm and materials of ductile cast iron or plastic (PVC and HDPE). The pipelines are listed below.

List of Raw Water Pipelines

Treatment Plant	Diameters	Distance
1) Luong Yen	200 - 600 mm	3,675 m
2) Yen Phu	200 - 400 mm	4,205 m
3) Ngo Si Lien	200 - 600 mm	4,650 m
4) Tuong Mai	200 - 300 mm	2,415 m
5) Mai Dich	225 - 600 mm	12,180 m
6) Phap Van	200 - 600 mm	1,700 m
7) Ngoc Ha	200 - 600 mm	3,810 m
8) Ha Dinh	250 - 400 mm	2,170 m
Total	200 - 600 mm	34,805 m

2.5.4 Distribution Pipelines

Water is distributed to the consumers through the distribution pipelines and networks. The basic framework of the distribution system is formed by the transmission mains. The transmission mains have two characteristic features: the pipe diameter is 300 mm or more, and service connections are not allowed directly from them. The transmission mains feed a secondary network of distribution mains. The distribution mains are mostly 60-250 mm in diameter and made of cast iron (before 1985) or plastic (PVC and HDPE after 1985). In many part of the urban center the town structure is unclear, and smaller distribution pipelines have not been installed to form a tertiary distribution network. In these areas service connections are made directly from the secondary network, leading to complicated systems. In the city center where a town structure exists, the tertiary network is being installed following international practices.

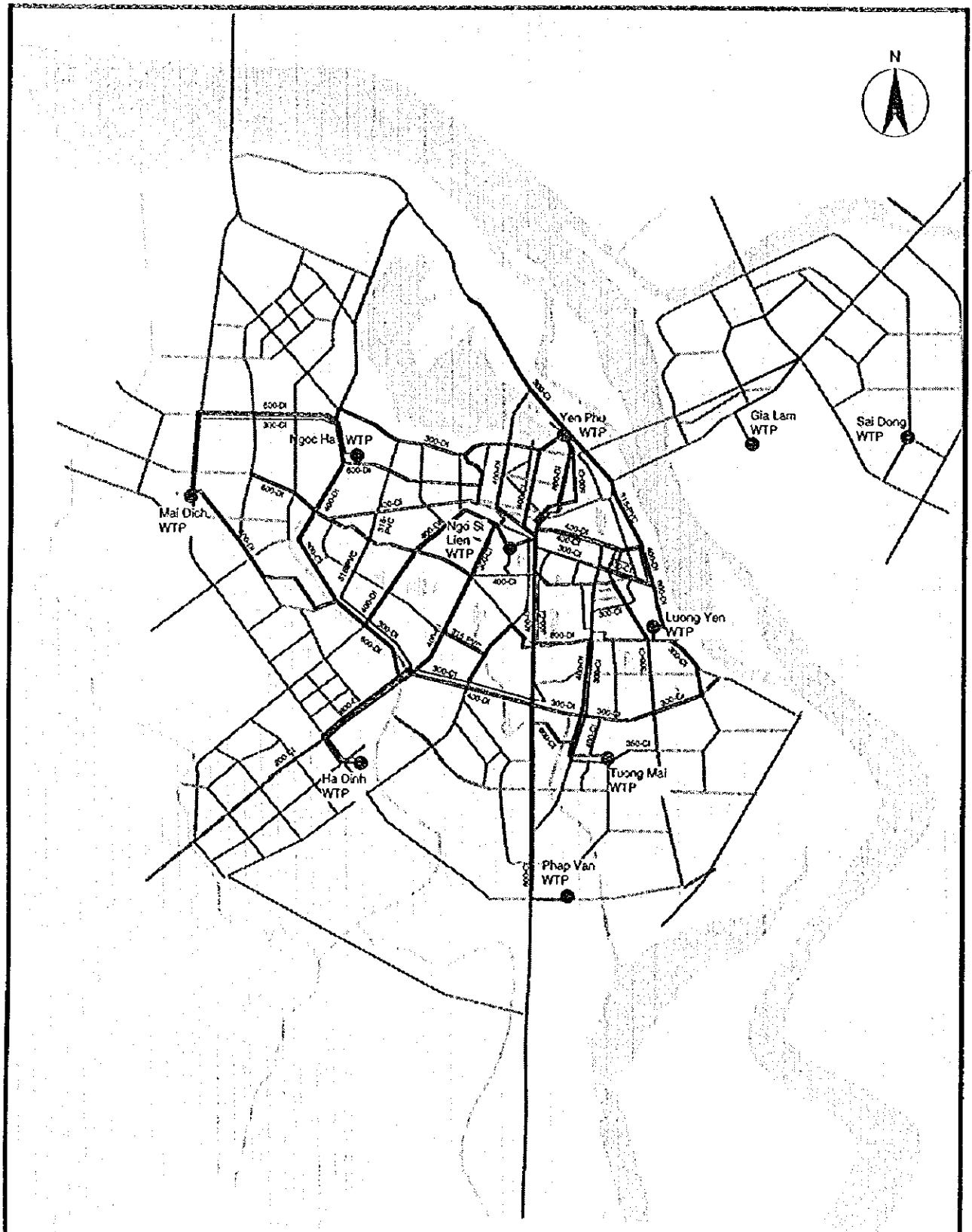
The transmission and distribution system is divided into two parts: the old network, covering most of the old city center and the southeastern Hai Ba Trung district, and the new network, constructed by the HWSP (Hanoi Water Supply Program by FINNIDA), covering the western and central part parts of the urban center. As of December 1995, the new pipes (328.2 km) occupied 64% of the total distance of 512.5 km, and the old pipes (184.3 km) 36%. With assistance from HWSP and further from the World Bank, the old network is being progressively withdrawn from service and by new pipelines.

The distribution pipelines, the old and the new, are listed in the following page, and transmission mains are shown in the following map.

WATER DISTRIBUTION NETWORK BY ENTERPRISES

(As of December 1995 , HWBCo)

DIA	OLD NETWORK (Constructed before 1985)							NEW NETWORK (Constructed in 1985 - 1995)							TOTAL
	Enterprise						Total	Enterprise						Total	
	Ba dinh	Dong da	Hai ba	Hoankiem	Tu liem	Gia lam		Ba dinh	Dong da	Hai ba	Hoankiem	Tu liem	Gia lam		
(mm)	(m)							(m)							(m)
600	-	6,150	-	-	-	-	6,150	9,083	3,050	9,945	1,250	9,800		33,128	39,278
500	350	-	100	2,197	-	-	2,647	-	-	-	-	-		-	2,647
400	7,155	5,067	4,970	4,576	160	2,150	24,078	5,499	5,067	11,785	3,494	5,499		31,344	55,422
350	-	-	-	500	-	3,010	3,510	-	-	-	-	-		-	3,510
315	-	-	-	-	-	-	-	-	3,696	125	2,165	212		6,198	6,198
300	1,680	7,100	9,840	-	2,100	1,950	22,670	7,130	554	-	-	-		7,684	30,354
250	2,140	710	3,300	770	-	2,720	9,640	-	-	-	-	-		-	9,640
225	-	-	-	-	-	-	-	7,632	5,295	2,786	3,533	2,783		22,029	22,029
200	3,743	2,550	5,670	6,922	4,900	4,310	28,095	-	65	-	-	-		65	28,160
160	-	-	-	-	-	-	-	19,863	16,163	7,367	8,780	6,985		59,158	59,158
150	1,625	-	11,111	2,517	590	4,810	20,653	-	-	-	-	-		-	20,653
110	-	-	-	-	-	-	-	10,730	30,514	13,310	13,160	3,665		71,379	71,379
100	5,037	1,000	18,011	17,108	4,440	7,920	53,516	-	-	-	-	-		-	53,516
90	-	-	-	40	-	-	40	7,615	19,701	51,771	7,440	7,989		94,516	94,556
80	-	-	-	512		-	512	-	-	-	-	-		-	512
75	-	-	-	3,497	-	1,870	5,367	-	-	-	-	-		-	5,367
63	-	-	-	-	-	-	-	-	2,658	-	-	-		2,658	2,658
60	-	-	-	7,461	-	-	7,461	-	-	-	-	-		-	7,461
Total	21,730	22,577	53,002	46,100	12,190	28,740	184,339	67,552	86,763	97,089	39,822	36,933	-	328,159	512,498
%	(4%)	(4%)	(10%)	(9%)	(2%)	(6%)	36%	(13%)	(17%)	(19%)	(8%)	(7%)	-	64%	100%



Distribution Networks in June 1996

2.5.5 Service Connections

Water is supplied to the consumers mainly by individual service connections and partly through public taps. The total number of the service connections was 136,922 at the end of April 1996.

At the same time, the number of public taps was counted at about 700. HWBC has determined to reduce the number of public taps by 20% annually, which is planned to be transferred to individual service connections.

Service Connections Registered

(As of 29 April 1996, HWBC)

Classification by Enterprise	Number of Service Connections Registered	Population Served	Persons per Connection
(1) Ba Dinh	44,054	193,167	4.38
(2) Hoan Kiem	10,996	90,896	8.27
(3) Dong Da	42,507	151,412	3.56
(4) Hai Ba Trung	26,726	116,351	4.35
Sub Total ((1) - (4))	124,283	551,826	4.44
(5) Tu Liem	12,354	36,912	2.99
(6) Gia Lam	285	684	2.40
Total ((1) - (6))	136,922	589,422	4.30

2.5.6 Fire Hydrants

Before 1994-1995, water for fire fighting work had not been relied on fire hydrants in pipelines systems of HWBC's public water supply. In fact there had been existed more than one hundred fire hydrants in the old water supply network; however, none of them had been used due to their non-functioning. At the time of fire happenings, fire fighting activities were carried out by fire fighting department, being under administration of police, using water which was available from natural surface water sources nearby the fire points, such as lakes, ponds, canals, rivers, etc. However, from bitter experience of a big fire case at Dong Xuan Market happened in early summer of 1994 (the fire fighting work was difficult due to lack of access to natural water, and the fire continued ceaselessly for several days), HPC established a new policy and ordered to HWBC to construct functional fire hydrants to be located on sidewalk pavement in strategic points at intervals of 300-350 m (or water tanks, to be located in open places such as public parks, constructed in semi-ground type reinforced concrete structure, keeping 50-100 m3 water for fire fighting) nearby main distribution pipelines.

As of June 1996, 19 fire hydrants were already installed for actual use, on pavement edge, being covered with bright red boxes, at major points in the city, and the number of fire hydrants is scheduled to be increased to 43 sites (in addition to 12 water tanks) within 1996; and furthermore to be 160 sites by the year 2010.

As fire hydrants are installed on main pipelines which have diameters more than 250 mm and formulate looped networks. Water flow requirement from fire hydrants is 50 l/sec in standard, and flow in a loop is 250 l/sec in standard; therefore, flow for fire fighting is judged to be secured as far as fire hydrants are installed on main pipelines.

2.5.7 Communal Water Supply Systems

There are three communal water supply systems administrated by People's Committee of towns or villages shown in Table 2.5-9.

Table 2.5-9 Communal Water Supply Systems

1. Name of District	Thanh Tri	Tu Liem	Tu Liem	Tu Liem
2. Location	Thanh Tri Town and surrounding area	Phu Dien Commune	Tay Tuu Commune	Me Tri Commune
3. Administration	District people's committee	Village level people's committee	Village level people's committee	Village level people's committee
4. Population	17,000	10,000	12,000	14,000
5. Facility	Operating (one treatment plant)	Operating (4 treatment plants)	Operating 1 plant, constructing 1 plant	Under constructing (3 treatment
6. Construction Cost	3.3 Billion VND	1.6 Billion VND	200 million VND/1 system	1 billion VND
7. Finance Source	HPC, District	UNICEF, District, Consumer	UNICEF, District, Consumer	HPC, District
8. System Capacity	2,500m3/day	2000 m3/day of Total 4 village	360m3/day	720 m3/day
9. Operation Condition	4 hrs per every day	6 hrs per every day	3 hrs to 5 hrs per every day	
10. Water Coverage	Vandien town, Vinh Qwynh village	Phu Dien (4 villages)	Tay Tuu (2 villages)	Me. Tri (3 villages)
11. Served Population	1,800 and Fertilizer Factory	7,000	4,200	14,000 (Design)
12. Service Rate	9.4 %	70 %	35 %	100 % (Design)
13. Service Level	House connection	House connection	House connection	
14. Water Tariff	1,000 VND/m3	1,500 VND/m3	1,200 VND/m3	
15. Billing system	By Water meter and flat rate	By Water meter and flat rate	By water meter	
16. System	Reconstruction in 1995	New construction in 1995	New construction in 1995	Depending on budget
16.1 Intake	2 wells, 120 m3/hr each	1 well each treatment plant(30m3/hr)	1 well (30 to 35m3/hr)	3 well (30m3/hr each well)
16.2 Aeration	Concrete structure	Concrete structure	Same as left	Steel tank fabrication
16.3 Filter	Rapid sand filter	Rapid sand filter	Same as left	Steel tank rapid filter
16.4 Reservoir tank	Ground type by concrete structure	Ground type by concrete structure	Same as left	Same as left
16.5 Distribution	3 pumps / Steel pipe	1 pump each treatment (28m3/hr)	1 pump (28m3/hr)	3 pumps (28m3/hr each)

2.6 RELATED WATER SUPPLY PROJECTS

2.6.1 Introduction

(1) On-going Projects

At present there are two on-going projects and some actual implementation plans for water supply improvement project in Hanoi. These projects and plans will contribute a great deal to the water supply of Hanoi in future.

The two projects are:
- World Bank Program
- JICA's Gia Lam water supply project,

For the formulation of the M/P by the year of 2010, recognition of these projects is important, since the water supply plan is based on current situation of water coverage and service population. And these on-going projects are not included in formulation of water supply plan in future, but the distribution capacity of these projects is considered as the existing capacity.

(2) Water Coverage

Water service area by the year 2000 was defined as Fig. 2.6-1 taking the two on-going projects into account; World Bank Program and JICA's Gia Lam Project.

(3) Population Served

Population served to be increased by the World Bank Program can not be distributed directly to new areas. Therefore, the number of service population was calculated at the almost some figure estimated by overlaying the future water coverage on the present one. As for JICA's Gia Lam Project, population served was estimated by the same manner. Predicted population served in 2000 is integrated in Table 2.6-1.

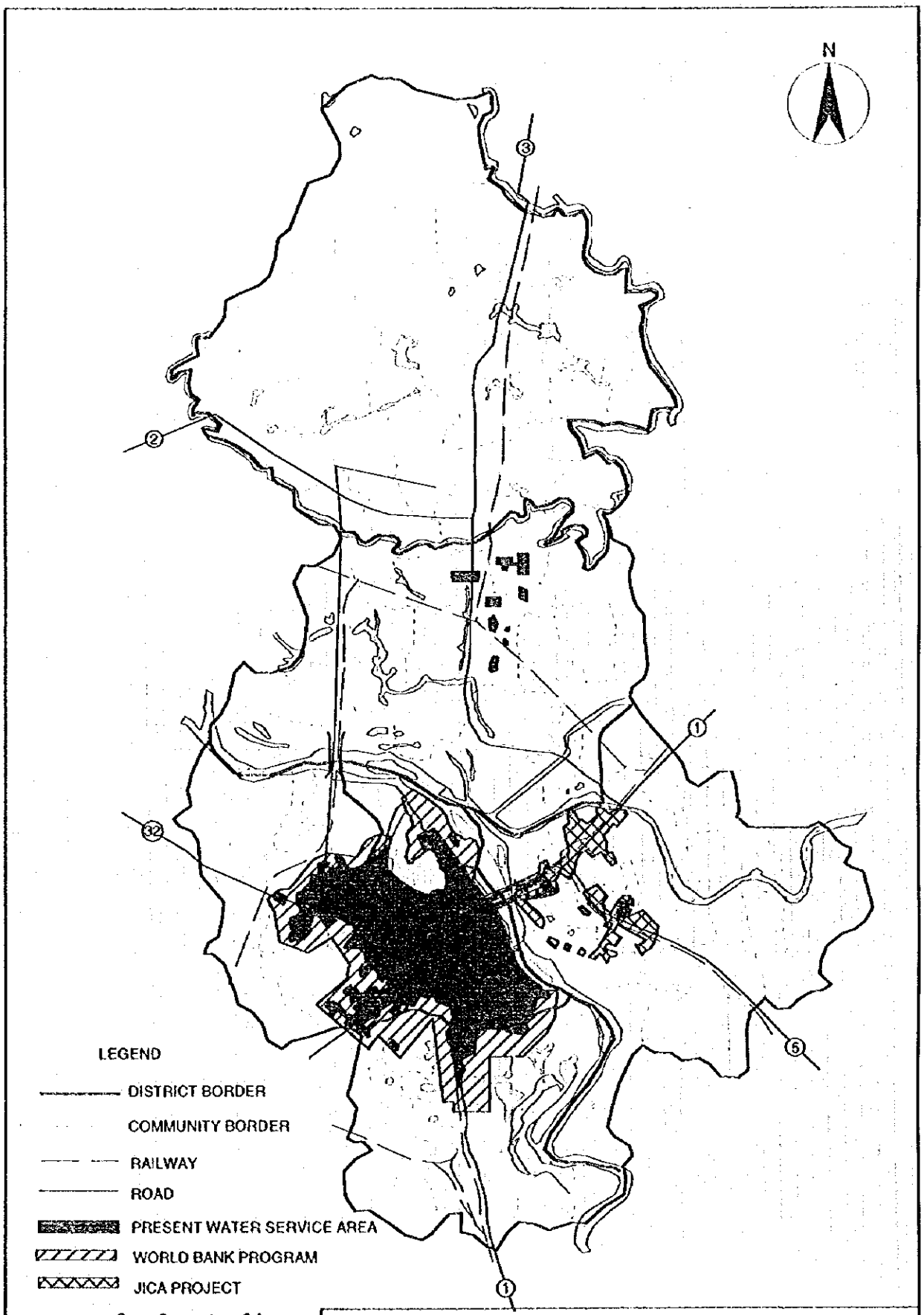


Fig. 2.6-1 Future Water Service Area (up to Year 2000) (predicted by Water Supply Programs)

Table 2.6-1 Future Population Served (Year 2000)

The North Hanoi

Area / District	Total Population	Piped Water System		Hand Pump System	
		Population Served	Rate	Hand Pump	Rate
DID	579,938	117,562	20.3%	195,000	33.6%
Soc Son	66,659	0	0.0%	14,040	21.1%
Dong Anh	238,239	8,269	3.5%	80,400	33.7%
Gia Lam	275,040	109,293	39.7%	100,560	36.6%
Rural	366,977	12,160	3.3%	190,920	52.0%
Soc Son	185,690	0	0.0%	86,160	46.4%
Dong Anh	91,567	0	0.0%	62,520	68.3%
Gia Lam	89,720	12,160	13.6%	42,240	47.1%
Total	946,915	129,722	13.7%	385,920	40.8%
Soc Son	252,349	0	0.0%	100,200	39.7%
Dong Anh	329,806	8,269	2.5%	142,920	43.3%
Gia Lam	364,760	121,453	33.3%	142,800	39.1%

Urban Area of the South Hanoi

District	Total Population	Piped Water System		Hand Pump System	
		Population Served	Rate	Hand Pump	Rate
Tay Ho	115,451	76,205	66.0%	29,860	25.9%
Ba Dinh	191,848	191,848	100.0%	0	0.0%
Hoan Kiem	173,556	173,556	100.0%	0	0.0%
Dong Da	359,066	332,024	92.5%	120	0.0%
Hai Ba Trung	337,044	337,044	100.0%	0	0.0%
Total	1,176,965	1,110,677	94.4%	30,000	2.5%

Suburban Area of the South Hanoi

Area / District	Total Population	Piped Water System		Hand Pump System	
		Population Served	Rate	Hand Pump	Rate
DID	446,548	241,548	54.1%	146,280	32.8%
Tu Liem	314,909	190,407	60.5%	98,280	31.2%
Thanh Tri	131,639	51,141	38.8%	48,000	36.5%
Rural	113,423	6,407	5.6%	99,120	87.4%
Tu Liem	29,052	4,200	14.5%	35,400	121.9%
Thanh Tri	84,371	2,207	2.6%	63,720	75.5%
Total	559,971	247,955	44.3%	245,400	43.8%
Tu Liem	343,961	194,607	56.6%	133,680	38.9%
Thanh Tri	216,010	53,348	24.7%	111,720	51.7%

The water service rate of the five urban districts is to become 94%. The rate of population served of two suburban districts adjacent to urban districts is expected to increase by 24% on account of the World Bank Project. The rate of the other three suburban districts will also increase by 33% after Gia Lam Project.

In the year 2000, the water service rate of Hanoi will become 55%.

According to Table 2.6-1, water service population to be increased by both projects is shown in Table 2.6-2.

Table 2.6-2 Increase of the Population Served

Year		1996	2000	Increase
Population Served	Urban Districts	1,100,085	1,110,677	10,592
	Suburban Districts	174,852	377,677	202,825
	Total	1,274,937	1,488,354	213,417
City population		2,394,887	2,683,851	-
Rate of population served		53.2%	55.5%	-

In Table 2.6-2, the increase rate of population served in urban district is still low, since population growth rate is low for four years up to 2000. Both on-going project contributes to increase of population served in suburban districts.

2.6.2 World Bank Program

HWBC has established an extension program to be financed by the World Bank for about 68% of the total cost. The World Bank mission made preappraisal for the program on 8 July 1996. The detail design work for the program is now in progress with Finish Government grant finance, and it is to be completed in September 1996. The construction work is scheduled to be implemented in years of 1997-2000.

The program components are summarized below, together with cost estimates.

Summary of World Bank Program

(Implementation period : 1997-2000)

Category	Component (Construction Work)	Quantity	Cost (*) US$ million
(A) Treatment Plant	(A1) Cao Dinh Plant (A2) Nam Du Tuong Plant	30,000 m3/day x 1 30,000 m3/day x 1	9.62
(B) Water Source	(B1) Wellfield for Cao Dinh (B2) Wellfield for Nam Du Tuong (B3) Replacement well in the existing wellfields	9 wells 9 wells 4 wells	1.89
(C) Network	(C1) Transmission pipelines (C2) Distribution pipelines (C3) Secondary / tertiary pipes (C4) Zone flowmeter (C5) Installation of new service connections (C6) Replacement of old service connections	21 km 80 km 250 km 25 – 30 Nos. 60,000 Nos. 30,000 Nos.	15.87
	Total (A+B+C)		27.38
	Consulting services, training cost, land acquisition, contingencies, etc.		20.52
	Grand Total (Budget)		47.90 (US$ million)

2.6.3 New Gia Lam Project

For Gia Lam district which is located east of the Red River, a new water supply system with capacity of 30,000 m3/day is now under progress. In August 1996, construction of a new treatment plant (30,000 m3/day) was completed, with grant aid assistance of the Japanese Government. As for distribution pipelines, a part of networks and service connections was already in use, as of August 1996. Construction of pipelines and service connections is to be expanded rapidly in coming months.

In Gia Lam district, although two small treatment plants (Old Gia Lam Plant 4,000 m3/d and Sai Dong Plant 1,000 m3/d) were existing, their capacity was not enough for whole Gia Lam people and facilities including distribution pipelines had been deteriorated. Therefore, this new Gia Lam water supply system will greatly contribute to people in Gia Lam district.

The new Gia Lam treatment plant is located almost at the center of Gia Lam district. The water source is groundwater and it is taken through 12 deep wells; four of which are located nearby the treatment plant and other 8 wells in the left bank of the Red River. As the groundwater contains high concentration of iron and manganese, the treatment process includes two steps' rapid sand filtration in order to remove iron and manganese respectively.

2.6.4 Yen Phu Extension Project

In Yen Phu treatment plant, an extension work is being executed with assistance of FINNIDA. The present capacity of Yen Phu is 40,000 m3/d and that of the new one is also 40,000 m3/d; making 80,000 m3/d in total. The water source is groundwater and 12 deep wells are to be constructed adjacent to the existing Yen Phu wellfields along the right bank of the Red River. The project includes the extension of distribution transmission pipelines. It is expected that after completion of the extension work, the northern part of Hanoi proper, south of the Red River, will be improved in the grade of water supply.

2.7 ENVIRONMENTAL CONDITIONS

2.7.1 Current Legislation Systems for Environmental Protection

(1) Laws and Regulations for Environmental Protection

1) Law on Environmental Protection

It was ratified by the National Assembly on December 27, 1993, and the statute was issued on August 18,1994. In this law, there are very clear articles to prevent environmental pollution in general, also articles concerning water supply. Chapter II concerns prevention and combat against environmental degradation, pollution and incidents. Article 15 mainly deals with protection of water resources and observation of public hygiene regulations. Article 20 concerns appropriate technology and environmental protection measures to be applied for searching, exploring, exploiting, transporting, processing, storing minerals and mineral products including groundwater. Article 38 defines responsibilities for environmental management.

2) Others

The Council of Ministers issued Hygienic Regulations and Administrative Penalty in Health Service in 1991 which are based on Organization Law and People's Health Protection Law. Chapter II of the regulations concerns hygiene for water and water resources for domestic use.

Besides laws, several proposals and environmental standards have been issued I recent years to enhance environmental mitigation and to prevent pollution.

"Law on Water" has no legal force yet, the draft currently being circulated for comments. The draft includes the following items:

- Exploitation and use of water resources and discharge of water
- Prevention and protection from harmful effects caused by water
- Prevention and protection from pollution of water resources
- Conservation of hydraulic works
- State administration of water resources

Law of Protection and Using of Historical-cultural Relics and Places of Scenic Beauty was promulgated in 1984. Decree No.288 of the cabinet council stipulated the implementation of the law in 1985.

(2) Administrative Organizations for Environmental Protection and Their Roles/Jurisdiction

The Ministry of Science, Technology and Environment (MOSTE) was established in 1992. It was reorganized from the former state Committee for Science and Technology. Main role of MOSTE is to assist the central government in planning of strategy and policy related to science, technology and environment. Within the Ministry, the Department of Environment and Natural Resources has a responsibility for environmental control. Before the set up of MOSTE, Vietnam did not have any administrative body to coordinate environmental issues on the government level.

The Ministry of Construction and the Ministry of Agriculture and Rural Development (former Ministry of Water Resources) are main administrative bodies of the central government level that are responsible for sanitation and wastewater disposal. The former is mainly responsible for design and implementation of urban water supply systems and for developing sector policies. It also supervises implementation of the projects through its design companies. The latter is responsible for development and management of surface water resources and mainly focuses on irrigation and flood control issues.

The sanitary tasks of the Ministry of Health are health education, promotion of appropriate water supply and sanitation, and water quality monitoring.

All urban activities in Hanoi are fallen under the control and jurisdiction of the Hanoi People's Committee (HPC). People's Committees of provinces and cities shall exercise their function for environmental protection at the local level. The following two departments which belong to HPC are mainly responsible for environmental protection in Hanoi. The Department of Science, Technology and Environment is responsible for encouraging and approving to apply new technologies to projects of public sector, and for ensuring that they have no

adverse environmental impacts. The Hanoi Hygiene and Epidemic Institute monitors water quality of surface water from the viewpoint of public health. Hanoi has a sanitation company in charge of solid waste disposal created in 1960, named Hanoi Urban Environment Company (URENCO).

Soc Son Forest is managed by Forest Management Department under Hanoi Agricultural and Forest Office. There are local working offices in this field; Soc Son Forest Management Company and Dong Anh Afforest Station. Parks, flower gardens and green zones along streets are managed by Hanoi Zoo, Park and Tree Company under control of Hanoi TUPWS.

Authorities responsible for management of cultural or historical properties are as follows :

- Ministry of Culture
- Social Sciences Commission
- Urban-Rural Planning Institute, Ministry of Construction
- Historical Research Institute
- Hanoi Planning Institute
- Hanoi Culture-Information Bureau
- Chief Architect Office

(3) EIA System and Necessary Procedures

In September 1993, the Minister of MOSTE (Ministry of Science, Technology and Environment) signed the temporary guidelines on EIA. This guidelines gave general conception and contents of an EIA report and determined organizations having a function of EIA reporting and a schedule of approving an EIA report.

The Law on Environmental Protection in Vietnam was approved by the National Assembly in December 1993 and was signed in force in January 1994. The Government Decree on providing a guidance for implementation of the Law on Environmental Protection was distributed in October 1994. According to this Decree, all of socio-economic development projects should be implemented with EIA reporting.

The available guidance does not require an EIA for domestic water supply projects.

In the final workshop of the feasibility study on water supply project financed by the World Bank, however, a vice-minister of MOSTE clearly spelled out that an assessment of environmental impact is needed as a necessary pre-condition for the government approval of the project. The costs for preparation of EIA and costs for appraisal of EIA report will be taken from the project's funds. An approval must be given within two months after receipt of the EIA report on the project.

The aims of EIA are as follows:

(a) Analyzing existing environmental conditions scientifically and forecasting future impacts as positive, negative, direct, indirect, temporary, long-term, on natural or socio-economic environment.

(b) To set up and propose measures for mitigation of negative impact combined with optimum alternatives for sustainable development.

2.7.2 Existing Environmental Conditions of the Study Area

(1) Natural Environment

1) Geography

Hanoi is a capital city which lies in the north of Viet Nam: at 21° north latitude and 106° east longitude. The distance between Hanoi and Tokyo is 3,675km. Hanoi is situated in the lowland plain of the Red River, and 75 km away from the west coast of Gulf of Tongking. The city borders five provinces; Bac Thai on the north, Ha Bac and Hai Hung on the east, Ha Tay on the west and Vinh Phu on the south.

The Red River runs through Hanoi from the north-west to the south-east. The city owes it to the river that there are plenty of water resources. There are extensive rice paddies in the north of the city, green, wooded and hilly countryside in the west that marks the beginning of the highlands, and rice fields in the south and east that stretch across the Red River delta to the coast.

2) Topography

Hanoi is situated on the delta of the Red River and the Duong River, and its topography mostly consists of flat areas with an average elevation of five (5) meters. The northern and north-western areas of the city have hilly features with elevation ranging from 20 to 400 meters. The elevation in the city decreases gradually from west to east and from north to south.

3) Geology

Hanoi situates on a part of the Bac Bo plain which can be broadly divided into two geological units.

- The Neogene formation belongs to the Pliocene. This unit forms a thickness of approximately 250 meters and consists of series of silt and claystone. Sandstone and conglomerate occur in the upper parts.

- The Quaternary unit belongs to the Early Pleistocene and the Late Holocene.

The Quaternary formation lies on the Neogene formation.

4) Soil

Soil in Hanoi region is made of alluvial deposits. Surface layer mainly consists of sandy clay. Under the surface layer, there is a sand and gravel layer with a thickness of 20 ~ 40m lying on a clay layer with a fluctuating thickness.

In Hanoi region, the Red River and the Cau River generated most soil that show a little acid to neutral and rich in mud contents and nutrients suitable for growing many kinds of plants.

5) Groundwater

Groundwater is available all around the city. Water bearing formation in the city consist of loose and alternating quaternary sediments. In general, there exist two aquifers. The deep one with the depth of 40 ~ 80m is the main aquifer that consists of gravel, cobbles and coarse sand.

6) Surface Water

Hanoi lies along the Red River bank. There are 19 large and small rivers with a total surface area of 32.6 km^2 in Hanoi. The Red River is the largest river that runs through Hanoi with a width of 1~1.5 km in the vicinity of Hanoi. It originates in the Nguy Son mountains in China. The reach of the stream which runs through Hanoi city has a length of 30 kilometers from Tu Liem district to Thanh Tri district. Flood season lasts for five months from June to October and the peak level of river water appears in August. Its flow fluctuates between 350 and 22,000 m^3/sec and its water level fluctuates between 1.7 and 14.1 m above mean sea level. About 75% of the river water is carried during rainy season and the remaining 25% is carried during dry season. Water of the Red River is not used for water supply in Hanoi, but it plays an important role for irrigation and waterway transportation.

The Duong River is a branch diverted from the left bank of the Red River in Hanoi, and runs through Dong Anh and Gia Lam districts.

The Nhue River is functioning as a main drainage which receives wastewater from the city. Its catchment area in Hanoi is 57.9 km^2 and the river water is used for irrigation.

Other rivers in the southern area of the Red River are To Lich River, Lu River, Kim Nguu River and Set River which are small and mainly functioning as drainage of the city. All sewage of Hanoi is discharged into these four rivers during dry season.

In the northern area of the Red River, there exist some medium-sized rivers which are mainly utilized for irrigation. The largest river is the Cau River which originates in the northern highland regions, runs through Bac Thai province and Ha Bac province, and finally reaches Hanoi. Its total catchment area is 5,780 km^2 and the length is 255 km. The Cong River is a tributary of the Cau River and its confluence with the Cau River is at Trung Gia on the northern boarder. The Cong River has a total catchment area of 951 km^2 and a length of 96 km. The Ca Lo River is also a tributary of the Cau River and it has a total catchment area of 881 km^2 and a length of 89 km. Annual average flows of these rivers are 51 m^3/sec (Cau River), 15 m^3/sec (Cong River) and 29 m^3/sec (Ca Lo River). Minimum flow of the Cau River is 4.3 m^3/sec and others are almost zero.

Hanoi has numerous lakes and ponds. The largest one is the West Lake that was created by separation when the Red River was embanked. Main functions of lakes and ponds are recreation, retention of storm water, regulation of microclimate, fish farming and receiving bodies of wastewater. In the suburban districts, lakes are utilized for irrigation and water supply.

7) Climate

As a northern region of Viet Nam, Hanoi has tropical monsoon climate. The climate is humid and hot with an average temperature of 30°C from May to October. Rainfall mainly occurs during the period from April to October. The climate is rather cold with an average temperature of 10~20°C during the period from November to April.

8) Wildlife

Wildlife in Hanoi seems to be very poor. Almost all wild animals were hunted for food, and capturing of rare and endangered species is another threat to fauna. Deforestation, industrial pollution and excessive usage of agricultural chemicals cause negative effects on wildlife. Hanoi is surrounded by vast delta plain covered with fields of rice and other crops, and trees are only found in small villages. Mountains in the northern part of the city were deforested a couple of decades ago and an intensive erosion has taken place on steep slopes.

Existing green areas in Hanoi are shown in Fig. 2.7-1, and nature preservation areas are as follows.

Cau Dien Nursery : It is located along the National Road No.32. It covers an area of 160,000 m^2 for cultivating saplings and an area of 600,000 m^2 for flowers.

Hanoi Zoo : It is located in Thu Le Park. It has a total area of 230,000 m2 including a flower bed of 1,900 m^2 and grass cover of 30,000 m^2.

Soc Son Forest : It is located in Soc Son district, and it has an area of 12,000,000 m^2.

Co Loa and Den Sai : It is located in Dong Anh district. It has a forest and green trees of 850,000 m^2.

Bach Thao Garden : It is a former zoo of Hanoi, it covers about 200,000 m2 with many old trees and valuable trees.

(2) Socioeconomic Environment

1) Land Use

A total area of Hanoi is 922.8km2. It consists of five urban districts and five suburban districts. Tay Ho district is the latest urban district that has been designated by the decision in December, 1995. In Vietnamese, an urban district is called "quan" and an suburban district is called "huyen". An urban district is, moreover, divided into sub-districts that are called "phuong" in Vietnamese.

In the course of time , the city center has expanded to the east (Gia Lam), the south-west (Thanh Tri) and the north-west (Tu Liem) urbanizing the areas which were formerly situated in the suburban districts. Today, the city center has an area of 51km^2. A total area of Hanoi covers about 18 times the city center. Most parts of the city are cultivated for agricultural purposes. In the city center, residential areas and commercial areas are situated. Fig. 2.7-2 shows existing and future housing areas. At present (year 1994), industrial areas cover an area of 537ha and they would expand to 990ha according to Hanoi Urban Planning Institute. Fig. 2.7-3 shows present land use and future industrial zones.

2) Population

Hanoi has a population of 2.39 million (year 1995) and an average population density of 27 persons/ha. About a half of the population are concentrating in five urban districts with an average population density of 207 persons/ha. Another half of the population spread over five suburban districts where an average population density is 14 persons/ha. Northern districts such as Soc Son and Dong Anh have lower population density of around 10 persons/ha due to isolation from the urban area by the Red River.

Present natural population growth is 1.6% in the urban districts, and 2.1% in the suburban districts. An age structure of the population in Vietnam generally shows that persons of 35~50 years old never represent the structure due to the war or there is a depression concerning 20~24 year-old persons due to the decrease of birth rate due to the war.

3) Community

From 1979 to 1991, Hanoi consisted of the districts: Me Linh, Dan Phuong, Hoai Duc, Thach That, Phuc Tho, Ba Vi and Son Tay, and most citizens of Hanoi were Kinh ethnic group and several small ethnic groups of Muong settled in Ba Vi district. However, there has been only Kinh ethnic group in Hanoi since 1992, because such district has belonged to different provinces such as Vinh Phu and Ha Tay since then.

4) Natural Disasters

Inundation usually occurred in many streets of Hanoi during rainy season. In urban area, flood occurs more frequently, that causes a lot of serious effects to social life, environmental pollution and damage to national economy. If a rainfall intensity exceed 50 mm/hr., inundated places will be more than 42 and equivalent to a length of 14,293 m along the street, and the flood will last for three hours. In 1994, 2,918 ha of rice paddies and 543 ha of vegetable fields were damaged by the typhoon No.6 and No.7. The areas inundated in 1994 are shown in Fig. 2.7-4.

The following measures are being taken against floods.

- Reinforcing and maintaining dikes
- Developing drainage systems
- Maintaining drainage systems (dredging of ditches, canals, lakes and rivers, preserving lakes and their surroundings)

5) Transportation

Economic development of Hanoi depends on conditions of transportation. Transportation facilities in Hanoi are shown in Fig. 2.7-5.

60 percent of goods and 70 percent of passengers reach the city via national road network. The road network is a radial structure with a multi-setting ring system. A total length of the road network is 295 km and a road density is 0.66 km/km^2 on average. The density is rather lower than international standard and it could be a bottleneck factor for future urban development. Hanoi has seven national roads;

Routes No.1, No.2, No.5, No.6, No.23, No.32 and Thang Long - Noi Bai highway.

Hanoi has two civil airports: Noi Bai and Gia Lam. Noi Bai airport is 30 km away from the center of the city. It is the biggest international and domestic airport in the northern area of Vietnam and is to be extended due to an increase of passengers. Gia Lam is domestic airport and 6 km away from the center of the city.

There are five railway stations serving directly for railway transport: Hanoi, Gia Lam, Yen Vien, Giap and Van Dien. There are also stations for future development such as Phu Dien, Ha Dong, Dong Anh, Bac Hong and Hoi Xa.

Hanoi has two main ports in the Red River: Khuyen Luong and Hanoi (former Pha Den). Khuyen Luong port is located in the southeast of the city and used for a freight port with a loading capacity of 700 tons/day. Hanoi port is located in the east of the urban area and used for a freight port with a loading capacity of 40,000 tons/day.

There exist 18 bus stations and 26 bus routes in the city.

A means of transportation in the city has been rapidly changed since the market economy was adopted. It is a typical change that a public transportation for passengers has decreased while a private transportation has increased. Travel modes of the citizens are classified as: bicycles 50-50%, motorcycles 30-35%, private cars 13% and public transportation 6-7%. There seem to be about 1,000,000 bicycles and more than 300,000 motorcycles.

A means of freight transportation of the city is classified as: land transportation (bus, car, etc.) 60-65%, railway transportation 8-10%, waterway transportation 20-30%.

6) Economic Activities

Industry of Hanoi is changing for a market economy. All industrial sectors are seeking the way to fit their activities and operations to a new system. Development plans for industrial sectors focus on renewal of technology, equipment as well as construction of synchronized workshops in each industry.

Minh Khai - Vinh Tuy, Thuong Dinh, Dong Anh and Van Dien - Phap Van are typical existing large-scale industrial zones in Hanoi.

Several development plans in Hanoi are proposed as shown in Fig. 2.7-3.

7) Living Facilities

A. Water Supply

Water supply services in the urban area of Hanoi are managed and operated by Hanoi Water Business Company (HWBC). Duties of HWBC are to supply safe and stable water to consumers, to construct and maintain water supply facilities, and to manage its finance, personnel and property. Major water treatment plants operated by HWBC are Ngo Si Lien (capacity: 60,000m^3/day), Yen Phu (40,000m^3/day), Luong Yen (45,000m^3/day), Tuong Mai (30,000m^3/day), Ngoc Ha (55,000m^3/day), Ha Dinh (40,000m^3/day), Phap Van (30,000m^3/day) and Mai Dich (60,000m^3/day). The total production capacity of these eight major plants and other fifteen small plants is 370,000 m^3/day, and about 1.3 million people are served by HWBC. HWBC has six enterprises that handle subordinate tasks such as collection of water charge or maintenance of pipeline network. Besides HWBC, there are four small-scaled public water supply systems that are managed by local people's committees. Some problems concerning existing public water supply systems has been pointed out. They are high unaccounted for water, poor institutional performance and low service level.

In addition to the public water supply systems, there are more than 200 private systems that are mainly managed by factories and enterprises.

B. Wastewater Disposal

At present , drainage system in Hanoi are used for both storm water drainage and domestic/industrial wastewater sewer. Most wastewater are directly discharged into roadside drains and channels without any treatment.

Some of existing facilities of wastewater treatment are not enough or not effective. Particularly, septic tanks are not correctly connected to existing drainage system.

In some cases, untreated wastewater overflow the treatment facility to the street. Kim Lien-Trung is only one existing sewage treatment plant in Hanoi, however it is out of function at present.

There are some factories install wastewater treatment facilities, however most factories discharge their wastewater into sewerage systems without pre-treatment. There exist wastewater treatment plants for hospital wastewater.

About 1,000 ha of the old city in Hanoi has a sewerage network with underground sewers of 80km. More than 3,100 ha of new zone has a sewerage network with underground drains of 30 km and open channels of 40 km. Total quantity of sewage in the urban area is estimated to be about 300,000 m^3/day including industrial wastewater of 100,000 m^3/day. Hydraulic gradient of sewers is low and facilities are not in good condition. The capacity of drainage systems is insufficient in a rainy season. Lack of cleaning of pipes and deterioration of the system have caused local flooding.

Four rivers with a total length of 40 km are functioning as receivers and carriers of the sewage and storm water in the urban area. They are To Lich, Set, Lu and Kim Nguu rivers. Finally, the Nhue River receives all water from these four rivers.

C. Solid Wastes Disposal

The total volume of domestic and street wastes generated in the city is estimated to be about 3,000 m^3/day. Density of solid wastes in Hanoi is relatively high due to high organic contents, high moisture and construction materials.

Construction wastes contain all materials for building or road construction. They are sometimes placed on the roads near the construction sites, and collected by URENCO (Hanoi Urban Environmental Company) free of charge. They consist of excavated earth, concrete, bricks, lime, stones, mortar, gypsum, metals, wood, etc..

URENCO collected 55,216 tons of construction wastes from January to October in 1995. The landfills for construction wastes are Tam Hiep (Thanh Tri district)and Bo De (Gia Lam district).

There are about 600 big companies which produce a large quantity of solid wastes. Only 40% of them have contracted URENCO for solid wastes disposal, and others dump their wastes in illegal dumps or in rivers. The total volume of industrial wastes generated in Hanoi is estimated to be 35 m^3/day or 7 tons/day.

Wastes are generally collected during night time between 6 p.m. and 2 a.m.. People put the wastes directly onto collection vehicles or deposit them on the streets. Besides, there is a day shift from 9 a.m. to 5 p.m.. People put the wastes into garbage containers and container trucks take the containers to the dumps in the daytime. Four enterprises under URENCO execute wastes collection in the urban districts. About 617,000 tons of solid wastes and about 45,000 tons of night soil were collected by URENCO in 1995.

Existing landfills are shown in Fig. 2.7-6. Most collected wastes are currently dumped in Me Tri landfill which is controlled not to pollute the environment. Me Tri landfill covers an area of 3.2 ha west to north of the urban area. There are several proposed future landfills which are under investigation. Soc Son landfill is designed to have its area of 50 ha and to be started in 1996. Tam Hiep landfill (5 ha) and Lam Du landfill (23 ha) are designed to be used till 2000. Wastes from several hospitals are incinerated. A pilot composting plant sponsored by UNDP has come into operation since 1993 and is producing organic fertilizer.

8) Historical and Cultural Sites

There are several archeological or historical relics found in Hanoi. Their locations are shown in Fig. 2.7-7

9) Areas where Construction of Large Projects may be restricted

Restricted areas are as follows:

Ba Dinh square quarter and surrounding area
Hanoi old street quarter (bordered with the following streets)

north	:	Hang Dau street (north)
west	:	Phung Hung street (west)
south	:	Hang Bong-Hang Gai-Cau Go street (south)
east	:	Tran Quang Khai-Tran Nhat Duat street (east)

Thang Long rampart quarter

Their locations are shown in Fig. 2.7-7.

(3) Pollution

1) Air Quality

The monitoring results shows that concentration values of CO, NO_2 and SO_2 in the urban area are higher than those of the suburban areas. Concentration of CO at Cua Nam (roadside of intersection) is 1.6 - 2.2 times higher than that at Phu Thuong (the point representing background level), NO_2 is 2.5 - 5 times higher and SO_2 is 1.5 - 1.7 times higher. However, the concentration values except TSP are still lower than Vietnamese air quality standards. TSP at Cua Nam is three times higher than the limit of the standards.

2) Water Quality

A. Groundwater

Groundwater is monitored by HWBC twice a year: dry season and rainy season. Groundwater quality generally meets the Vietnamese environmental standards or WHO's guidelines excluding iron, manganese and ammonia in some parts of the city. High concentration of ammonia observed in southern part of the city seems to be related to pollution caused by decomposed sewage leaking into an aquifer. Another possibility is that such high concentration of ammonia is due to the decomposition of organic matter such as peat overlaying an aquifer.

B. Surface Water

Urbanization and industrialization in Hanoi is under developing with high speed. However, most pollutant sources never have install their wastewater treatment systems. Therefore, industrial and municipal wastewater causes pollution of water bodies in Hanoi. Some hospitals discharge their wastewater directly into drainage system in the city.

In general, self-purification capacity of lake system in the urban area is good. However, effluent without any primary treatment are discharged into lakes and the quantity of the effluent has increased. It results in serious polluted situation of some lakes such as Giam, Van Chuong and Linh Quang.

In general, water quality of the Red River and the Duong River seem to be still good. However, other rivers in the city seem to be seriously affected by wastewater. Kim Nguu, To Lich, Lu and Set are the river which link with sewerage systems and function as main drainage system of the city. Their concentration values of BOD_5 are ranging from 14 to 150 mg/l.

In the rural area, river water has been worried by contamination caused by agricultural chemicals such as fertilizer or pesticide.

3) Noise and Vibration

Road traffic is a major source of noise and vibration in the urban area of Hanoi. The monitoring results show noise levels in the daytime are higher than the limit level of the Vietnamese noise level standards by 4 - 9 dB(A), and those in the nighttime are higher than the limit level by 17 - 23 dB(A).

The monitoring results show vibration levels are nearly reached to the permissible limit for human body. Those are caused by bad quality of roads, narrow streets, etc..

4) Land Subsidence

In the regions within a few kilometers along the rivers, there is a close relationship between groundwater and rivers through the hydrogeological "windows". Groundwater level has not been considerably lowered by exploitation in these regions, because river water seems to recharge groundwater. Therefore, these areas are rich in groundwater resources enough to locate production wells. On the other hand, there is no close relationship between groundwater and river in the regions far from the rivers. Groundwater level easily decline, because discharge volume often exceeds recharge volume in these areas. In the southern area of the Red River, contour map of groundwater level shows a shape of cone of depression.

Groundwater exploitation seems to have lowered groundwater level and caused soil subsidence in Hanoi City. However, relationship between groundwater exploitation and land subsidence has not been clarified well. According to the land subsidence

study conducted by Vietnamese Geological Survey based on the monitoring network, the following results were reported.

The area of land subsidence is coinciding with an area having soft soil layers such as mud, peat and organic soils. The thicker the soft layer is, the more the settlement is. In the area along the Red River without soft layers, settlement does not occur. The settlement has decreased over the period of years (1988-1995) because of stable exploitation: from 58 mm/year to 35 mm/year in the area of strong land subsidence, from 38 mm/year to 21 mm/year in the area of medium land subsidence, and from 19 mm/year to 5 mm/year in the area of weak land subsidence

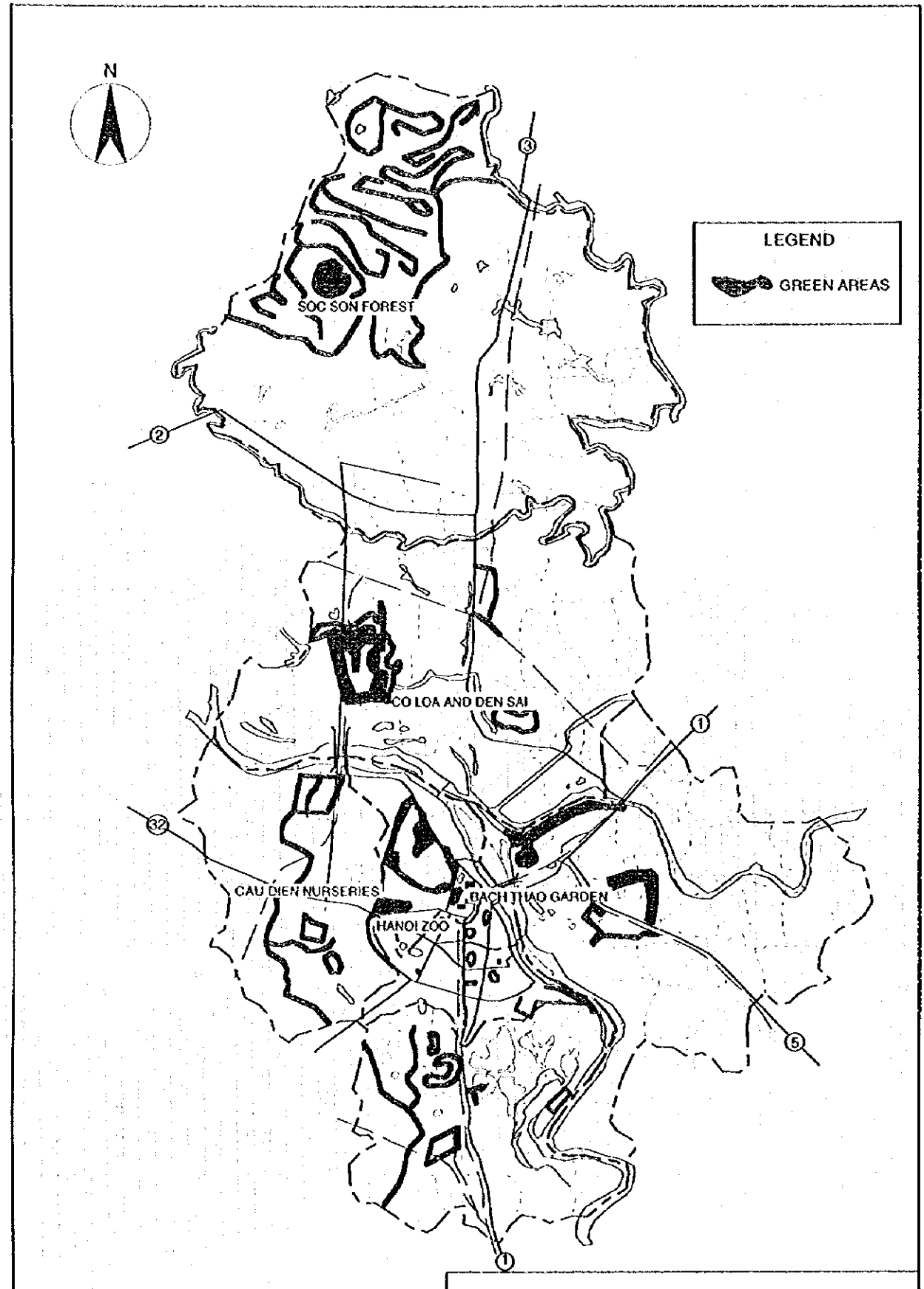


Fig. 2.7-1
Distribution of Existing Green Areas

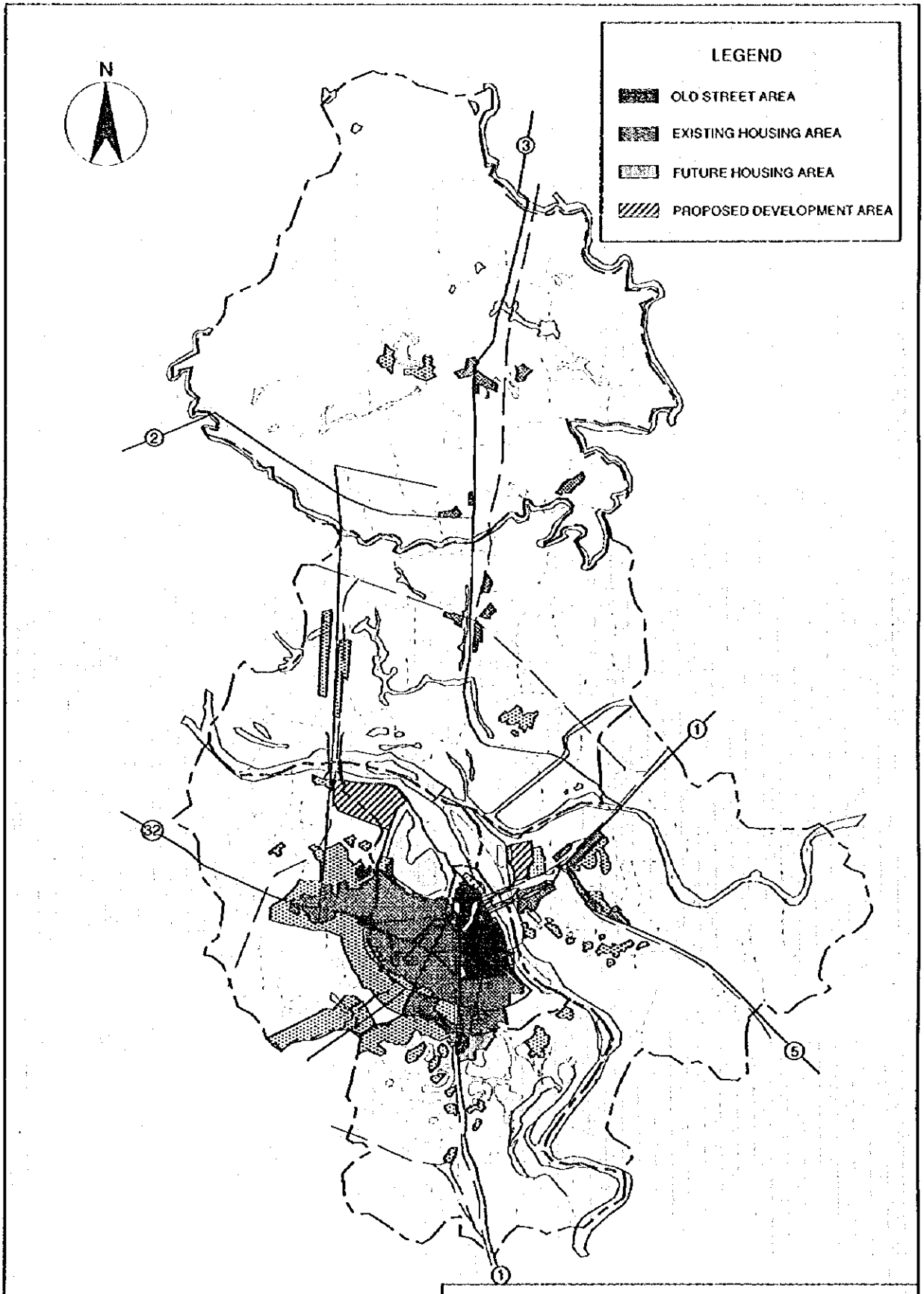


Fig. 2.7-2
Existing and Future Housing Area

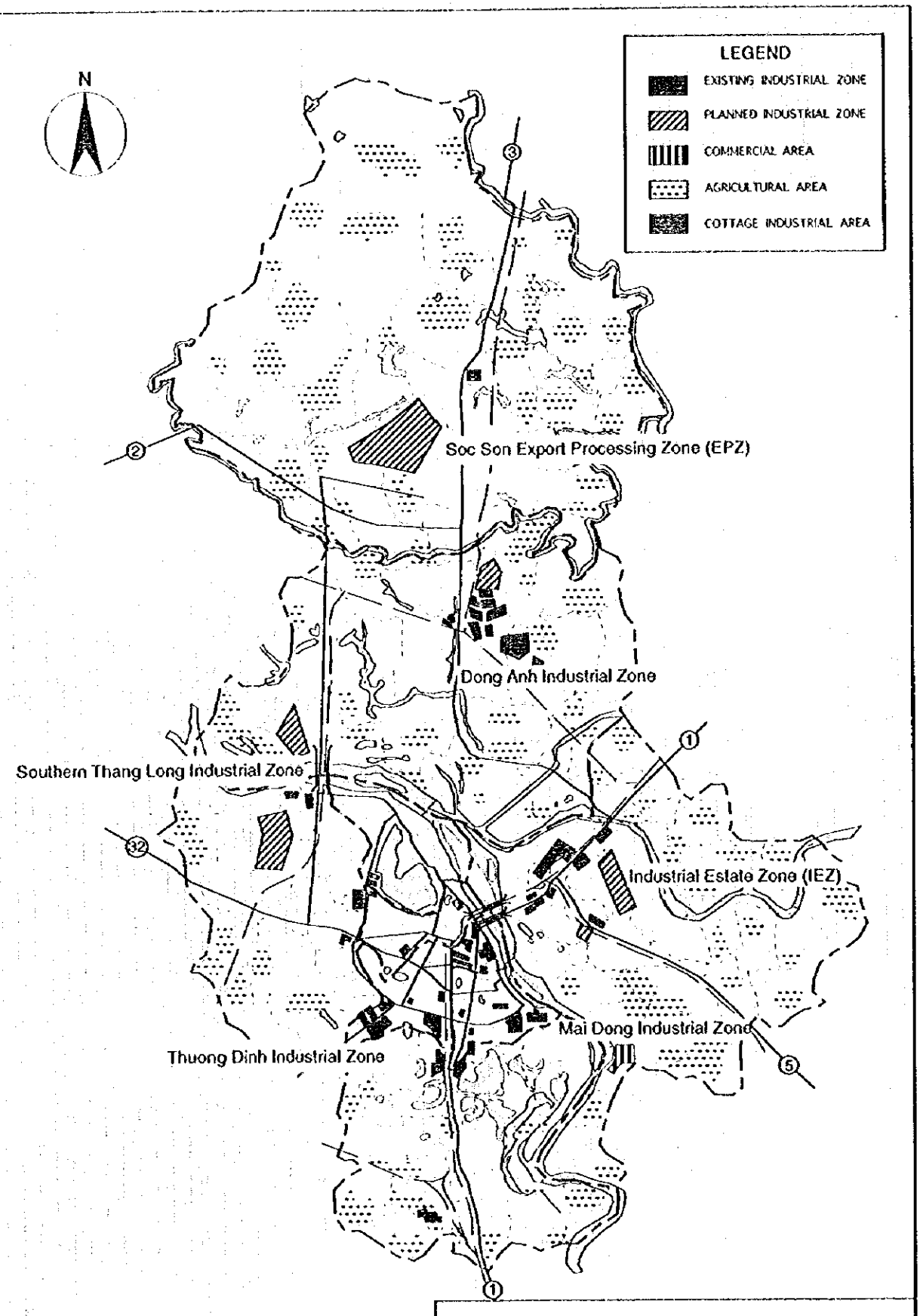


Fig. 2.7-3 Present Land Use and Future Industrial Zones

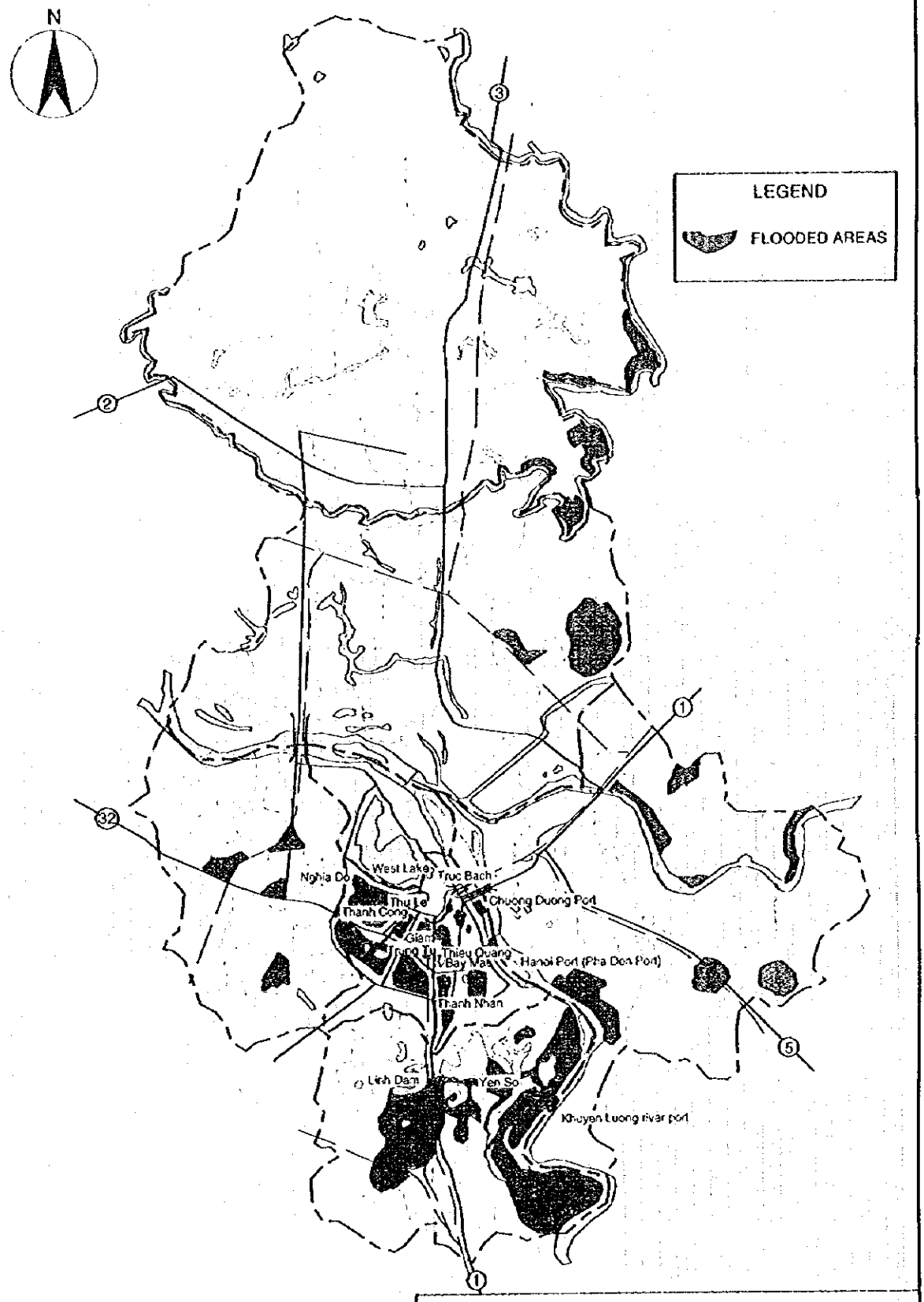


Fig. 2.7-4
Distribution of Innundated Areas in 1994

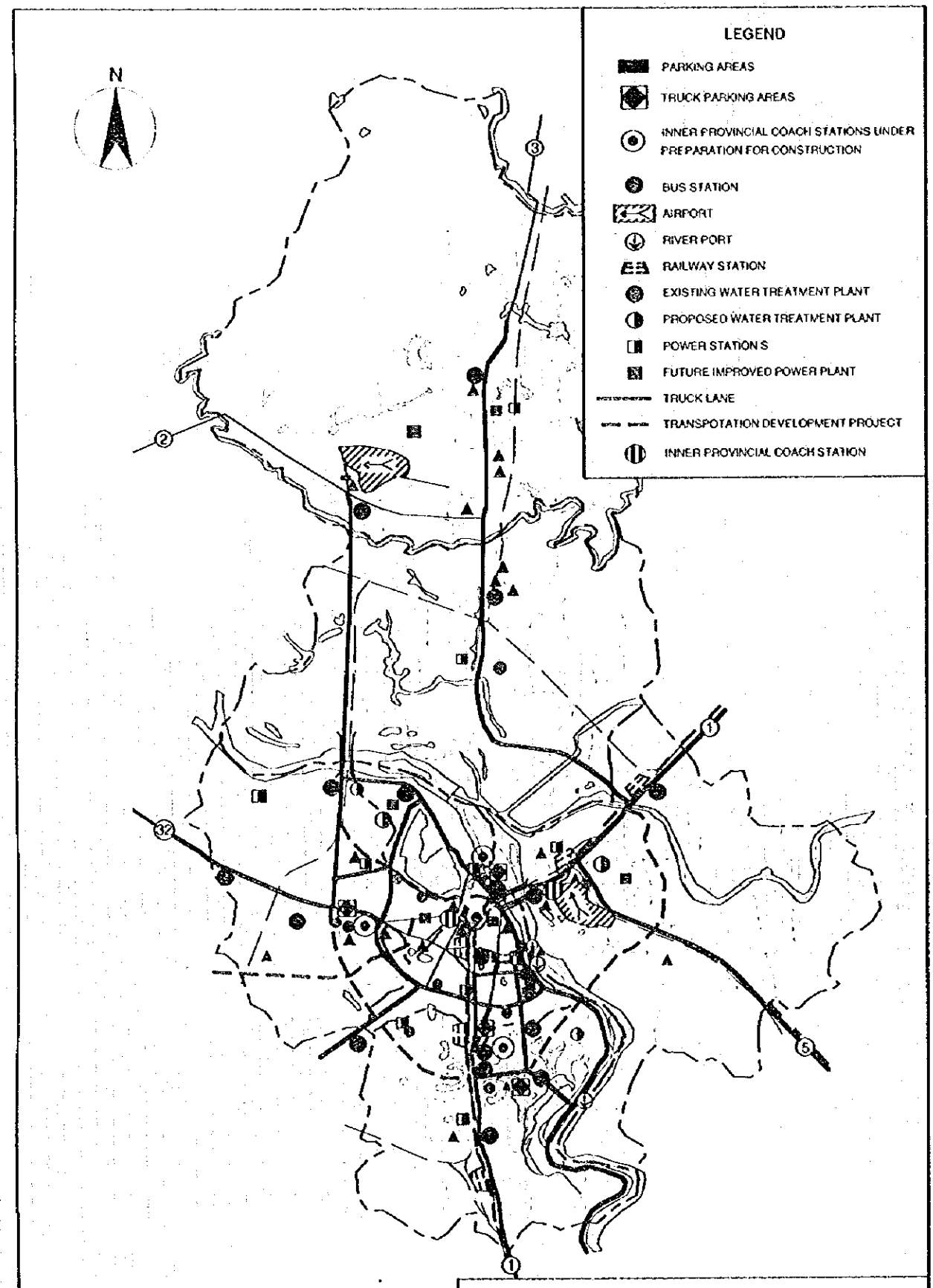


Fig. 2.7-5
Transportation and Urban Facilities

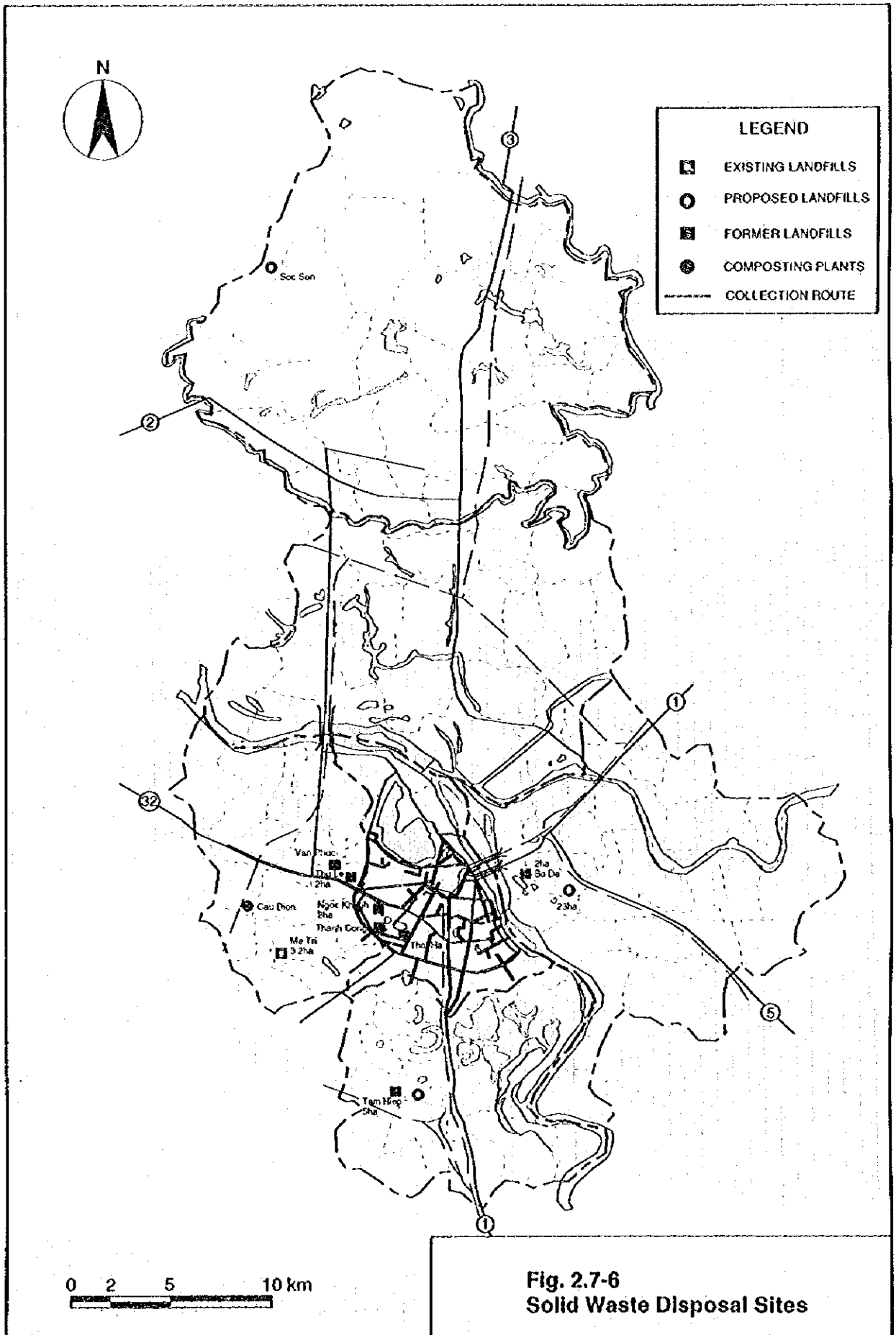


Fig. 2.7-6
Solid Waste Disposal Sites

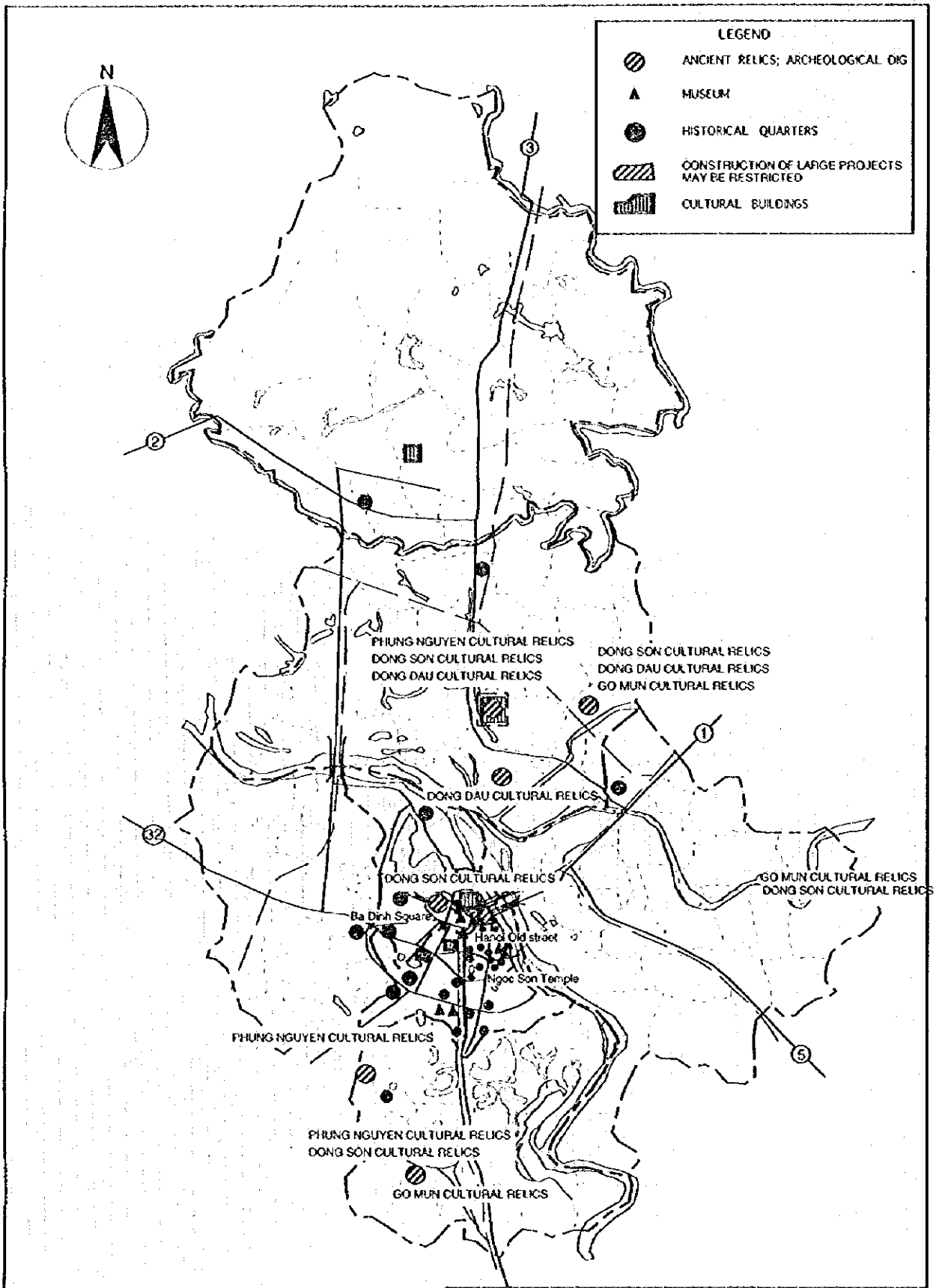


Fig. 2.7-7
Cultural and Archeological Relics

2.8 SUMMARY OF ISSUES

2.8.1 Technical Aspects

(1) Rate of Population Served

At the core of Hanoi City and its outskirts, at present, the rate of population served shows as high as nearly 100%. On the other hand, however, in its suburban area, the rate is still low at approximately 14%. Thus, the rate of population served in the entire Hanoi city is calculated at 53% on average.

Many people in non-piped water supplied areas desire safe and sufficient water supply by way of piped water system. People in these areas get water for their domestic use from poor water sources such as shallow wells, rain water, irrigation ponds or channels. Their water consumption in general is quite small.

(2) Water Sources

1) Groundwater

Ministry of Agriculture and Rural Development has been authorized to approve and permit everything related to the development of the water resources with the "Decision of Prime Minister" dated May, 1996 (Ministry of Water Resources had been authorized before). Laws and regulations related to the development of the water resources, particularly from the viewpoint of water resources protection, however, are still under preparation and have not been enacted yet. Therefore, at present, there is no actual control of the development of the water resources.

In the water resources development, the groundwater development through private wells in particular is required to be controlled theoretically from the view point hydrogeology, in order to avoid serious environment impacts. Therefore, immediate enactment and effect of the laws and regulations are desired.

2) Water Quality

In the whole city, groundwater contains high concentration of iron and manganese which do not meet the criteria for drinking water. In the southern part of the south Hanoi, groundwater also contains high concentration of ammonia. Although data are not enough, slightly high concentration of toxic substances such as cadmium, lead or phenols were detected in some wells.

(3) Facilities

1) Water Distribution

Domestic water is not necessarily obtainable whenever wanted; or rather, water is intermittently supplied in some places and in some months.

Although the total production capacity is apparently reasonable and satisfactable, people are not able to actually enjoy public water supply. It is because of the fact that the produced water is not distributed enough to consumers evenly, because of physical loss in pipelines, wastage at upper stream of pipelines, etc.

Therefore, it is strongly required to remedy such adverse conditions, by replacement work of old pipelines, and with efforts to reduce administration losses.

2) Water Quality

The treatment practice of the treatment plants is basically appropriate to the raw water quality, except plants in Phap Van, Tuong Mai and Ha Dinh, where high concentration of ammonia (8 - 25 ppm) presents in raw water which is not able to be removed by the current process. Furthermore, iron removal at Tuong Mai and Ha Dinh plants seems to be a problem (treated water : 1.3 - 1.5 ppm Fe) probably due to technical defects of filters.

As to tap water quality of end users, it could be said to be satisfactory to consumers in general, as a result of water quality analysis and personal interviews carried out at ten points in the city during April-May 1996. All of ten samples of tap water presented residual chlorine of 0.07 – 1.0 ppm.

3) Facilities

Facilities in water treatment process are judged to be in reasonable conditions in general. Although mechanical troubles and difficulties happen sometimes, they are usually not fatal, but they can be repaired or replaced with ordinary routine work or by some budget for repair cost.

Raw water intake facilities such as deep wells, intake submersible pumps and raw water pipelines tend to be deteriorated and to lose their original capacities, comparing with facilities in treatment plants. Accordingly, special attention for maintenance and inspections shall be paid to these intake facilities.

2.8.2 Institution and Management

(1) Unaccounted-for Water

The most serious problem in the water supply system in Hanoi is the extremely high level of unaccounted-for water (UFW, 70% of total production capacity). Administrative cause seems to amount to 45% and it is the major part of the total UFW.

(2) Credit Quality Lowering

When HWBC borrows the funds from the World Bank and foreign governments, the credit quality (=bankability) is the most serious thing. Credit Quality becomes lower due to the cutting of government subsidies, as it is difficult for HWBC to expect the governmental financial assistance. Low credit quality leads to high interest rate expenses and low availability of loan.

(3) Poor Marketing Activities

When we look at the staff/customer comparison surveyed by SPC (former State Planning Committee, present Ministry of Planning and Investment) and MOC in 1995, the ratio employees per 1000 connections in Hanoi recorded 16.6 higher than that of HCMC at 6.5, Khanh Hoa at 11.6, Thanh Hoa at 16.0. This shows that HWBC has too many staff.

(4) Under-estimation of Depreciation Cost

As fixed assets has not yet re-evaluated in the price movement of around 244% over 1990~1994, profits of HWBC may be pointed out as over-calculation due to the under-estimation of depreciation cost from the viewpoint of the international accounting standards.

(5) Potential Conflicts of Interest in Decision Making

The board of directors of HWBC seems presently to involve in the combination of ownership and management. Ownership function results from the present situation that fixed assets of HWBC belong to TUPWS or HPC and that directors, managers of HWBC are mostly appointed or approved by TUPWS or HPC.

Potential conflicts of interest have existed because that the board of directors not only perform the ownership function on behalf of HPC, but also is responsible for managing HWBC toward profit based efficiency. Under the circumstances the board of directors would face a dilemma whether water charges should be kept at an affordable level, or, at the level that allow the company to cover costs and make future investments.

To keep the affordable level of water charges means that the government continuously give subsidies to water consumers via HWBC. This has resulted in weak motivation to workers of collecting water charges. Additionally HWBC could not have the self-funding ability for replacement of fixed assets.

(6) Poor Motivation System

At the moment, the water plants and the business enterprises in HWBC are defined as internal cost units and introduced internal cost accounting. This means to place workers low profit responsibility.

(7) Out-of-dated Accounting System

The company's fixed assets are formally owned by TUPWS, although they are stated in the balance sheet of HWBC. This is different from the international accounting standards. There are two alternatives for countermeasures.

(8) Financial Status

1) Standard Difference from IAS

The New Accounting System has been officially applied from January 1. 1996, however, financial practice of HWBC is still apart from the International Accounting Standard (IAS). Currently in Vietnam some officials in the Ministry of Finance and the General Auditing Office have just started to gain IAS training, and independent auditors are still scare resource.

On surface, by the financial statements submitted by HWBC, historical performance of HWBC has not been that bad, however, proper accounting process has not been made. For example, revaluation of fixed assets has not been done in due course, thus depreciation charges were too low to show the real replacement cost. This results in difficulties in assessment of creditworthiness of the company, and furthermore, difficulties in formulating future Master Plan.

2) Weak Fundraising Ability

Present funding ability of HWBC is quite vulnerable.

(a) Due to accounting standard difference, credit assessment is difficult for external fund providers for both governmental and private sources. Although the London Club negotiation has just started to break the ice, private sources represented by international commercial financial institutions are still cautious to extend credits to State Enterprises (SEs) in Vietnam.
(b) Owing to the primitive financial market in Vietnam, it is currently difficult for SEs including HWBC to obtain long-term finances at a reasonable pricing from domestic sources.

In order to change the situation, structural improvement of financial market is necessary.

3) Insufficient Water Tariffs

Historically, water tariffs in Vietnam has been kept lower than full cost recovery level. As for Hanoi, cost of water supply is estimated 3,900 VND/ m^3 according to the opinion letter by HWBC/TUPWS to NWTS dated March 1996 (breakdown not available). Even after recent raise in August 1996, water tariff for domestic customers are just 1,200 VND/m^3. This is cross-subsidized by non-domestic customers, however, earliest effort to raise water tariff is required, same suggested by the World Bank and the Asian Development Bank.

4) Lack of Expertise

In respect of finance, lack of expertise in staffs in present HWBC is a major concern. In order to improve financial practices to international level, much expertise should be gained by managers and clerks in Finance Department and Business Department of HWBC. Two major issues should be covered urgently:

(a) lack of expertise in international accounting practices, and
(b) expertise in automated equipment and computers.