SUPPORTING REPORT B

MASTER PLAN

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CHAPTER 1 FRAMEWORK FOR THE MASTER PLAN

1 FRAMEWORK FOR THE MASTER PLAN

1.1 STUDY AREA

The study area covers approximately 924.5 km² consisting of five urban districts (Ba Dihn, Hoan Kiem, Hai Ba Trung, Dong Da and Tay Ho) and five suburban districts (Thanh Tri, Tu Liem, Dong Anh, Soc Son and Gia Lam) in Hanoi.

The urban districts and suburban districts in the study area differ in the water consumption conditions due to the living standards. Some areas in suburban districts will be urbanized by the development plan in future and likewise the residents' living standard will be improved. The new urbanization area consists of residential, commercial, institutional and other public areas depending on population growth. Therefore, the formulation of the water supply plan is based on the grouping by type of the area.
In this Study, the study area is categorized into three groups described as below:

(1) Group U : The core of Hanoi that consists of the five urban districts and the surroundings of the two suburban districts. The area has been supplied with water by public water supply. At present, the rate of population served in the area already amounts to 94 %.

(2) Group D : The future development area planned by Hanoi People's Committee and Densely Inhabited Area (hereinafter called DID) area in the five suburban districts of which population density is forecast to be more than 20 persons/ha. in 2010. It is assumed that the area will be rapidly urbanized due to the new development plan in future. On the other hand, the surrounding areas of the core of Hanoi will be rapidly developed as a bed-town of Hanoi city.

(3) Group R : This area is sparsely populated as agricultural farm lands. Farmers inhabit there following the farming conditions. Total population in this group is estimated at 16% of the population of whole Hanoi in the year 2010.

The area categorized into the above three groups is shown in the map of Fig. 1.1-1.

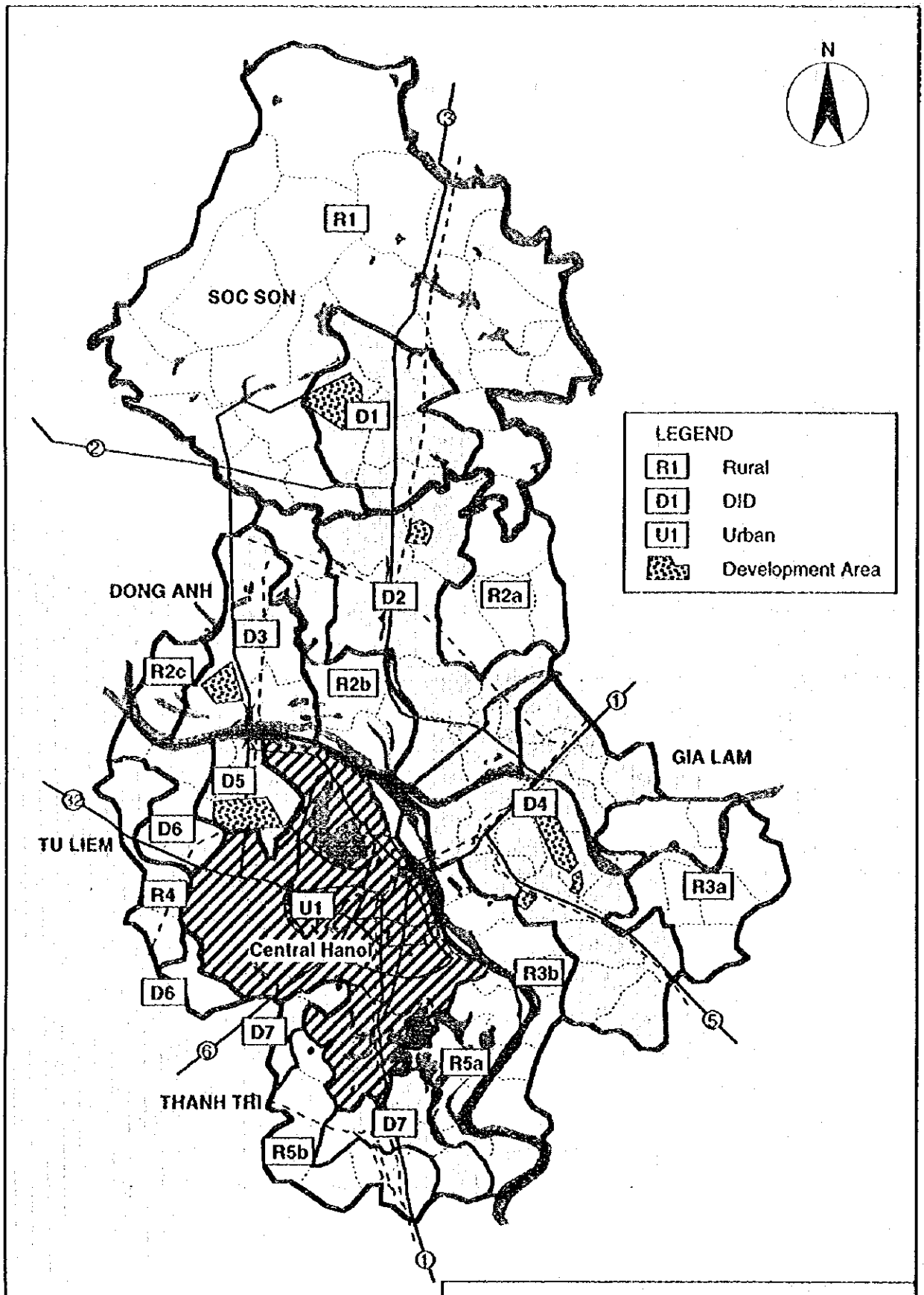


Fig. 1.1-1
Three Gruops of the Study Area

1.2 TARGET YEAR AND GOAL

The target year of the Master Plan is the year 2010. The final goal of the Master Plan is to achieve the suitable improvement of living standards and the promotion of healthy socio-economic activities depending on implementation of a suitable project for to providing the people of Hanoi with systems for adequate city-wide water supply.

The following is tangible contents of the target year and the goal:

(1) Improvement of the Existing Facilities

In order to strengthen finance of the waterworks, the rate of UFW, that consists of physical loss and administration loss, should be improved by 30% from 71% of the current status. UFW improvement is projected as Table 1.2-1.

Table 1.2-1 Projection of UFW Improvement

	1996	2000	2005	2010
Physical Loss	25%	21%	16%	15%
Administration Loss	46%	32%	21%	15%
UFW Total	71%	53%	37%	30%

(2) Extension Program of the Water Supply Systems

Service level of Group U and D is to be 24-hours consecutive water supply by way of house connections. Group R is to be served with sufficient water by way of public taps.

Service conditions of the water supply systems are shown in Table 1.2-2.

Table 1.2-2 Service Conditions of the Water Supply

	2000		2005		2010	
	Unit Water Demand (l/c/d)	Rate of Population Served (%)	Unit Water Demand (l/c/d)	Rate of Population Served (%)	Unit Water Demand (l/c/d)	Rate of Population Served (%)
Group U	150	100	165	100	180	100
Group D	105	100	135	100	165	100
Group R	60	30	75	85	90	85

(3) Institutional Strengthening

The urban water supply systems are proposed to be operated under self-standing conditions such as self-financing and self-autonomy.

As for the rural water supply systems, the construction management board would be organized in TUPWS. The facilities are to be constructed by the management board with subsidies. After construction, the systems are to be transferred to HWBC/HWBC No.2 for their operation and maintenance works.

1.3 URBAN DEVELOPMENT PLAN AND POPULATION FORECAST

1.3.1 Urban Development Plan

(1) Existing Land Use

1) Five Urban Districts

Hoan Kiem centers around Hoan Kiem Lake and the Old City which remains as the commercial center of Hanoi. Ba Dinh district is the seat of government offices with its center at the Ho Chi Minh Mausoleum.

Hai Ba Trung has the French Quarter, located in the south of Hoan Kiem Lake and the southward extension of the French Quarter. It is a mix of residential, commercial, administration, and educational uses. Tay Ho is newly included in the urban area and rapidly expanding of the city. There are developing of new residential and commercial estates with high standard comparing with Old City.

The eastern part of the urban areas, namely Hoan Kiem, Hai Ba Trung and Tay Ho are planned areas while most of the western area shows disarray of development.

Large areas of multiple dwellings existing in Dong Da district which includes central railway station and stand in rows in a regular fashion shops with the low residential areas penetrated by only narrow street. When the government constructed apartment houses to the west of the station to settle people in Hanoi, the area consisted of farming villages with large areas of paddy fields. Multiple dwellings of modern structure were constructed surrounding the existing villages.

2) Suburban Districts

Soc Son and Dong Anh, located in the north of the Red River, comprises largely of agricultural households. Gia Lam is located at the cross-roads of national highways No.1 and No.5. It has been industrialized rapidly. Tu Liem is located in the west of urban districts and its east fringe to the urban areas is becoming urbanized rapidly. Thanh Tri is the district located in the south-east corner of Hanoi. The area is subject to frequent flooding. Water bodies comprise a large part of the district.

(2) Land Use Plan for 2010

With a rapid increase of the population, the urban area has considerably expanded to the suburban area. The Government of Vietnam is controlling the flow of rural migration to the city and disordered expansion of urban function. A policy could control land use of Hanoi to new settlement of industries and residents.

The presented Study Team's forecast of Hanoi's population is based on a relatively preferable urban environment of Hanoi as the urban center of the region as well as capital city of the nation. The expansion of urban Hanoi means conversion of agricultural land to urban uses. The certain area of agricultural land included in the urban area depends on the size of urban expansion within Hanoi city.

Main land use targets are summarized as follows:

- Reducing population density in the historical city center, at same time increasing the densities in suburban areas which are now still low.
- New residential areas in south-west, west and north-west of the present urbanized area and Gia Lam area, will be developed.
- Existing residential areas in south of West Lake will be changed to public and green area.
- The main object in development of public areas is to establish blocks of offices and institutes, industrial and commercial settlements, tourism area and cultural activities in northern, southern and north-eastern coasts of the West Lake. Besides, a group of offices and institutes and other public services will be allocated equally in each area of city.
- Small industries will be also allocated evenly in the planning area of the urban area. The type of these small industries must be environmentally accepted.

Method for formulation of future land use is shown in the following sheet.

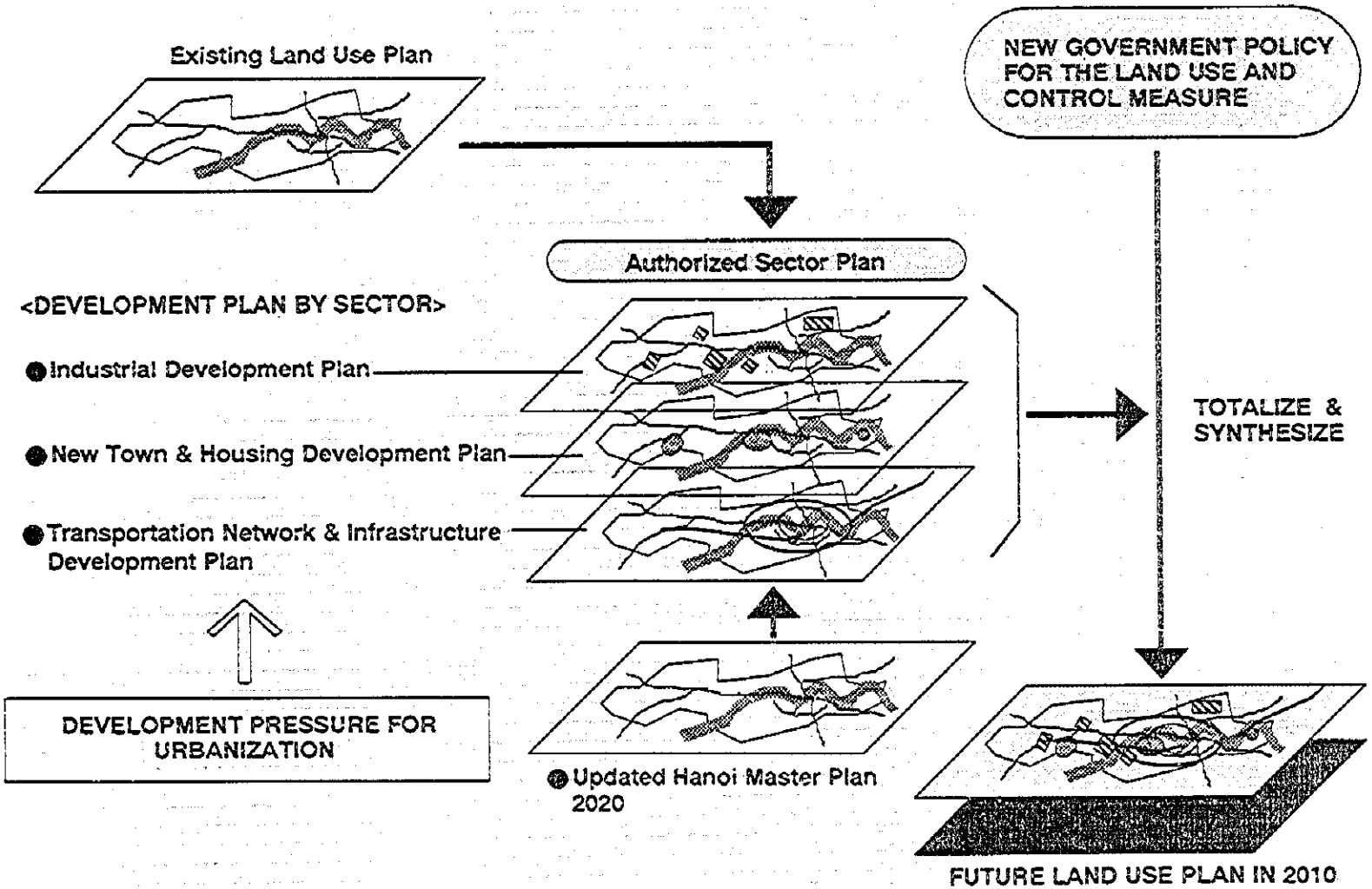


Fig.1.3-1 METHOD FOR SYNTHESIZE OF FUTURE LAND USE

(3) Urban Development Plan for 2010

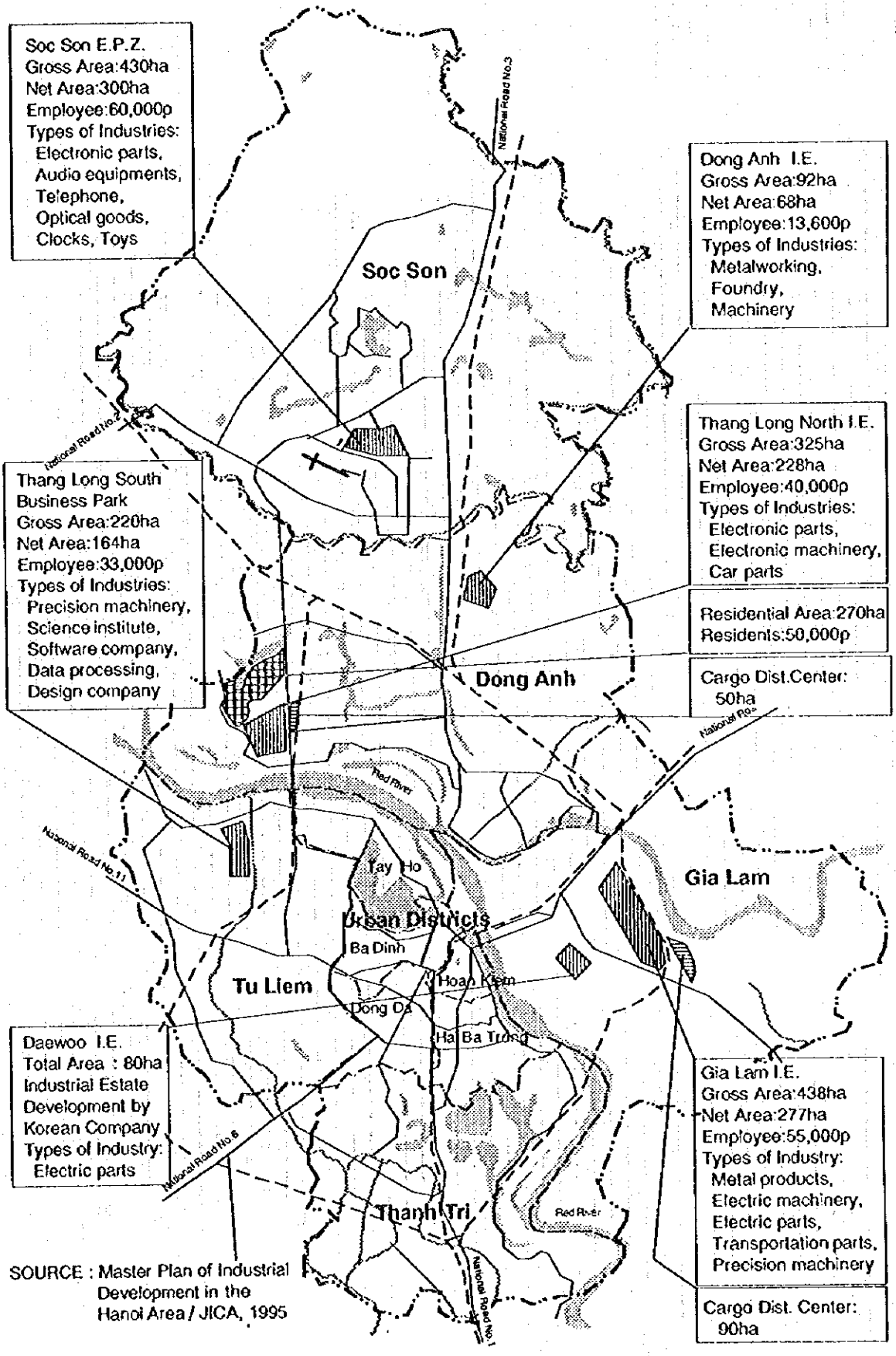
1) Industrial Development

At present, some industrial establishments are scattered in the urban area but there have also been established concentrated industrial areas located both in urban and suburban area.

Basic policy of industrial development in Hanoi follows the idea that main industrial establishments will be concentrated in separate zones in which each zone consists of certain types of industries having relatively similar characteristics.

There are in total five industrial zones in land use planning for future which was authorized by past JICA study of "Master Plan of Industrial Development in the Hanoi Area".

From a viewpoint of water supply, said JICA study suggested that water supply be constructed by developers themselves of industrial estates. However, more practical water supply policy will be established by the further study in this project.



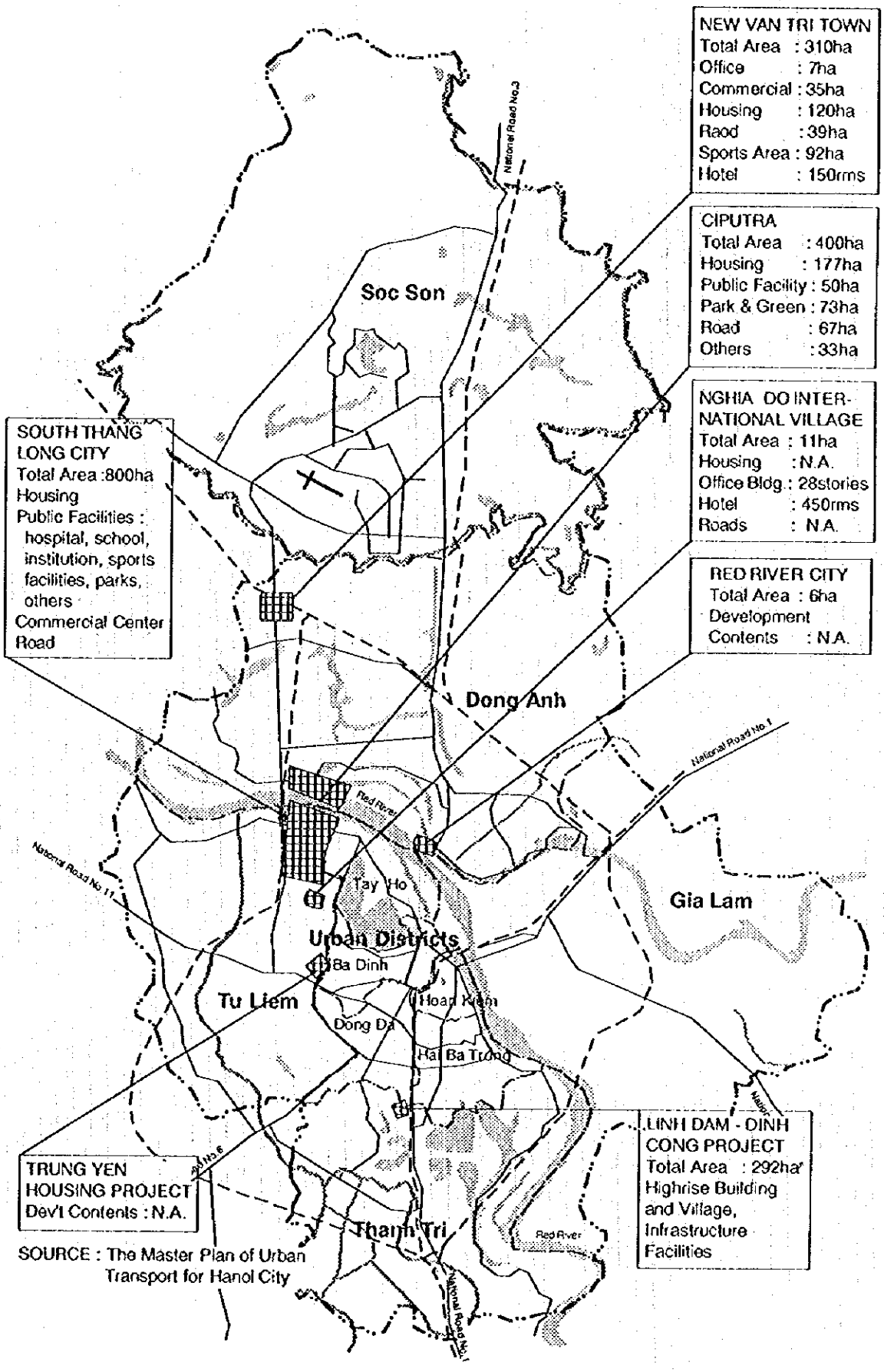
SOURCE : Master Plan of Industrial Development in the Hanoi Area / JICA, 1995

Fig.1.3-2 PLANNED INDUSTRIAL DEVELOPMENT PROJECT

2) City and Housing Development

There are many plans of commercial development as a new town and housing estates. But, some plans do not mention development outline. However, most of these development will be accumulated for future trend of water demand consisting of social activities with population growth.

Planning or on-going projects are shown in following sheet.



SOURCE : The Master Plan of Urban Transport for Hanoi City

Fig.1.3-3 PLANNED CITY AND HOUSING DEVELOPMENT PROJECT

3) Future Land Use Plan in the Target Year

Future land use plan for Hanoi city in 2010 is appeared from formulation of before-mentioned development plans.

These trends of urban development will reflect to the demand of urban water supply by category such as commercial use, industrial use, institutional use, mixed use, residential use, village area, green and park area, water area and others.

The materials of this plan were received from Hanoi city development plan by the National Institute for Urban and Rural Planning (URP) of the Ministry of Construction in collaboration with Hanoi Urban Planning Institute (UPI).

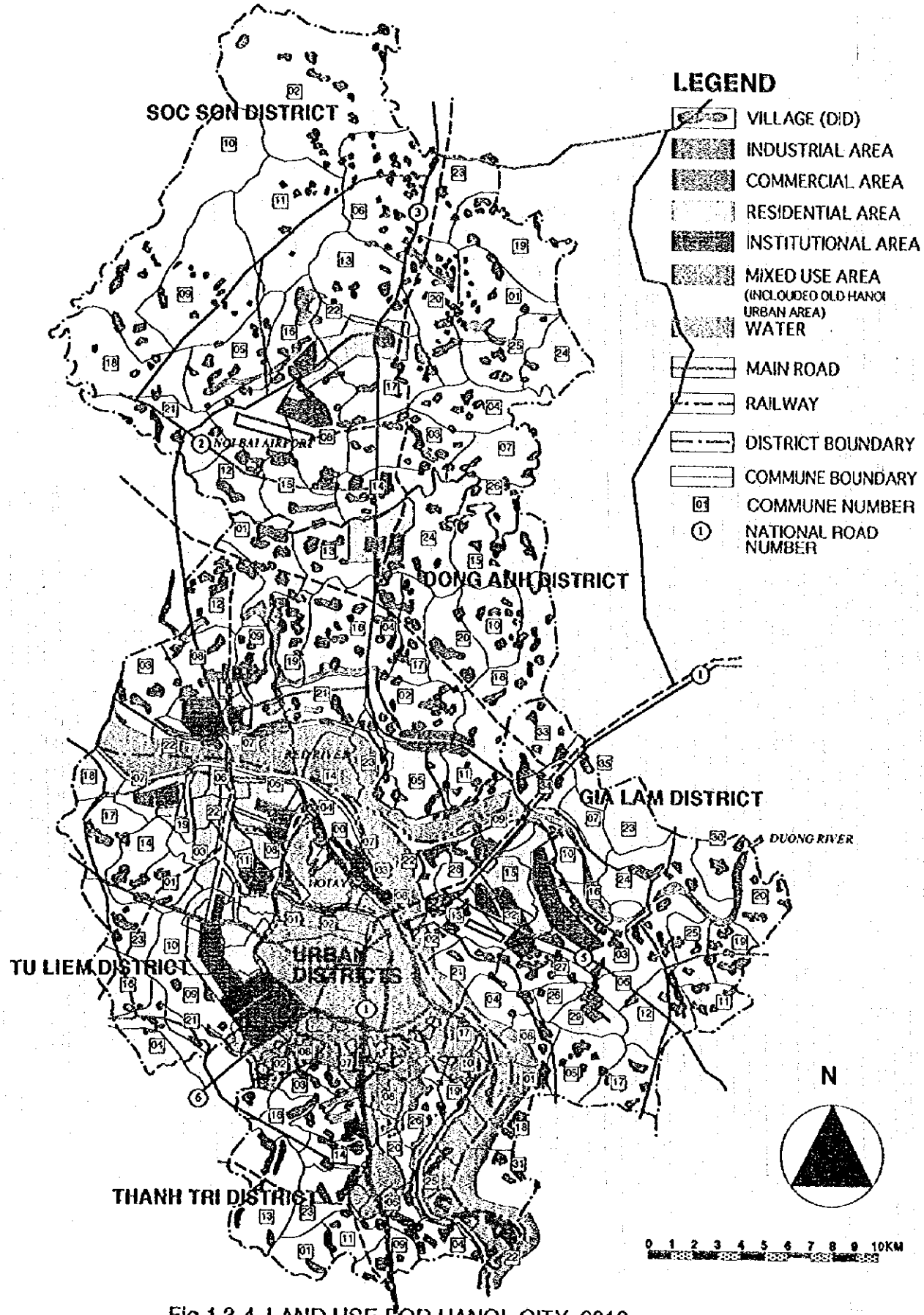


Fig.1.3-4 LAND USE FOR HANOI CITY 2010

4) Implementation Plan

The implementation period for the industrial estate is followed by the past JICA study which was authorized by the Government of Vietnam. Other development schedule is not shown clearly in this moment. Tentative development schedule for the planned projects in suburban area is summarized in Fig. 1.3-5.

Year	1995	2000	2005	2010
INDUSTRIAL ESTATE				
1. Thang Long North IE		1st phase 330ha	2nd phase 330ha	3rd phase 330ha
2. Thang Long South IE (or CBD)			220ha	
3. Dong Anh IE			92ha	92ha
4. Gia Lam IE		1st phase 367ha	2nd phase 528ha	3rd phase 528ha
5. Soc Son EPZ (or IE)		1st phase 100ha	2nd phase 300ha	3rd phase 430ha
6. Other IE(Daewoo, Taiwan,etc)		80ha	80ha	80ha
Total Area		**877ha**	**1,550ha**	**1,460ha**
•NEW TOWN & HOUSING ESTATE				
1. New Van Tri Town		(10ha)	(150ha) 310ha	(150ha)
2. Ciputra New Town			(300ha) 400ha	(100ha)
3. South Thang Long City		(100ha)	(350ha) 800ha	(350ha)
4. Nghia Do International Village		11ha		
5. Red River City				6ha
6. Trung Yen Housing Project			N.A.	
7. Linh Dam - Dinh Cong Project				292ha
Total Area		**121ha**	**(800ha++)**	**(898ha)**

Fig.1.3-5 DEVELOPMENT SCHEDULE FOR PLANNED PROJECTS IN SUBURBAN AREA

1.3.2 Population Forecast

(1) Present Conditions

Table 1.3-1 shows the population distribution of Hanoi in recent year. It indicates a heavy concentration in urban areas, especially in Old City, gradually thinning out towards the west and south. As for the land acreage, urban area of the city occupies only 6.7% of the whole Hanoi city area, although it has a half of population settled. Tay Ho is a new district in the urban area located at fringe of Ho Tay Lake. This district is newly urbanized area with still low density comparing to the other four districts. Along the corridors of Highways No.1, No.6 and No.32, the population spreads out to west and south. It is observed that the Red River has effectively intercepted the expansion of urban areas to the east.

Table 1.3-1 Population Changes by Districts

		1979 census	1989 census	annual increase 1979~1989	1995 statistic	annual increase 1989~1995
Urban	Tay Ho	-	-	-	80,638	-
	Ba Dinh	150,544	185,342	2.1%	187,558	0.20%
	Hoan Kiem	153,575	162,955	0.6%	193,504	2.91%
	Dong Da	220,673	266,161	1.9%	381,365	6.18%
	Hai Ba Trung	218,843	291,481	2.9%	347,289	2.96%
Total of Urban		743,635	905,939	2.0%	1,190,354	4.66%
Suburban	Soc Son	144,474	199,243	3.3%	211,186	0.97%
	Dong Anh	164,597	213,092	2.6%	221,229	0.63%
	Gia Lam	221,195	260,668	1.7%	302,566	2.52%
	Tu Liem	162,827	227,023	1.8%	250,076	1.62%
	Thanh Tri	162,827	190,610	1.6%	213,655	1.92%
Total of Suburban		883,153	1,090,636	2.1%	1,198,712	1.59%
Total		1,626,788	1,996,575	2.1%	2,389,066	3.04%

(source)
Statistical Office of Hanoi "Statistical Data in Urban Hanoi in 1979, 1989, 1995"

In rural areas the trends diverged in two directions, in Thanh Tri and Gia Lam, the population increase accelerated while the population in Soc Son, Dong Anh and Thanh Tri was increasing slightly.

Number of households in 1995 is summarized in Table 1.3-2.

This data was received from Hanoi Police Department Office. It indicates a number of households and population by District for the whole city. The data of average family size were calculated from this data and number of household were adjusted based on the present population by statistic data.

The average family size in whole city is 4.19 persons per family with 571 thousand households.

Table 1.3-2 Number of Households in 1995 (Summary)

District	Acreage (ha)	Population (persons)	Density (persons/ha)	Number of Households	Average Family Size (persons)
Tay Ho	1,907.8	80,638	42.3	19,794	4.07
Ba Dinh	915.8	191,286	208.9	49,970	3.83
Hoan Kiem	417.2	193,504	463.8	47,573	4.07
Dong Da	1,484.6	391,686	263.8	102,010	3.84
Hai Ba Trung	1,108.0	347,289	313.4	83,311	4.17
Total of Urban	5,833.4	1,204,403	206.5	302,658	3.98
Soc Son	31,466.9	211,186	6.7	42,771	4.94
Dong Anh	18,920.0	221,229	11.7	51,011	4.34
Gia Lam	13,810.0	302,566	21.9	70,785	4.27
Tu Liem	9,125.2	241,848	26.5	55,383	4.37
Thanh Tri	9,905.7	213,655	21.6	48,480	4.41
Total of Suburban	83,227.8	1,190,484	14.3	268,430	4.43
Total of Hanoi	89,061.2	2,394,887	26.9	571,088	4.19

(2) Analysis of Growth

The newest population data of Hanoi city were referred from the statistic data issued in 1995 by Hanoi Statistic Office.

Future population of the city is estimated in relation to considerable reference data such as annual average population growth, economical growth, trend of industrial and commercial development. It is necessary to corporate structural changes into the forecast method.

One thing which is understood is that Hanoi will pursue industrialization following with its ambitious economical growth rated 8.8% on GDP in 1994. Industrialization means more urban job opportunity created especially at early stage of industrialization. Under this condition, people would like to look for better income opportunities in a large city and the businessmen want to invest in a favorable location in terms of infrastructure, proximity to market, and support services.

Hanoi offers an attractive location for the investors in these aspects. New towns, industrial and/or commercial estate will be built in the suburban area of Hanoi. According to this movement, the largest factor of population pressure for Hanoi comes from social migration instead of natural population growth.

Based on the statistics, the natural population growth in Hanoi has over 30 years been greatly reducing from 3.89% in 1960 to 1.73% in 1991. This is partly due to social reasons such as; higher education of people, improved living conditions, so that more time is demanded to be reserved for other activities, increasing number of working women, methods and policies of government to restrict and control the population growth, application of contraceptives is popularized, etc.
Based on an official population projections for Hanoi, there are remarkable related studies such as:

- "Water Master Plan of Hanoi City by FINNIDA in 1993",
- "Water Supply Project, Feasibility Study by World Bank in 1994",
- "The Study on Urban Drainage and Wastewater Disposal System in Hanoi City in 1995" and

- On going project "The Master Plan of Urban Transport for Hanoi City by JICA, Interim Report issued on Mach 1996"

These projects were projected future trend of population.
From these authorized study and recent data should be considered on this projection.
Study procedure of population forecast shows in the attached flow chart.

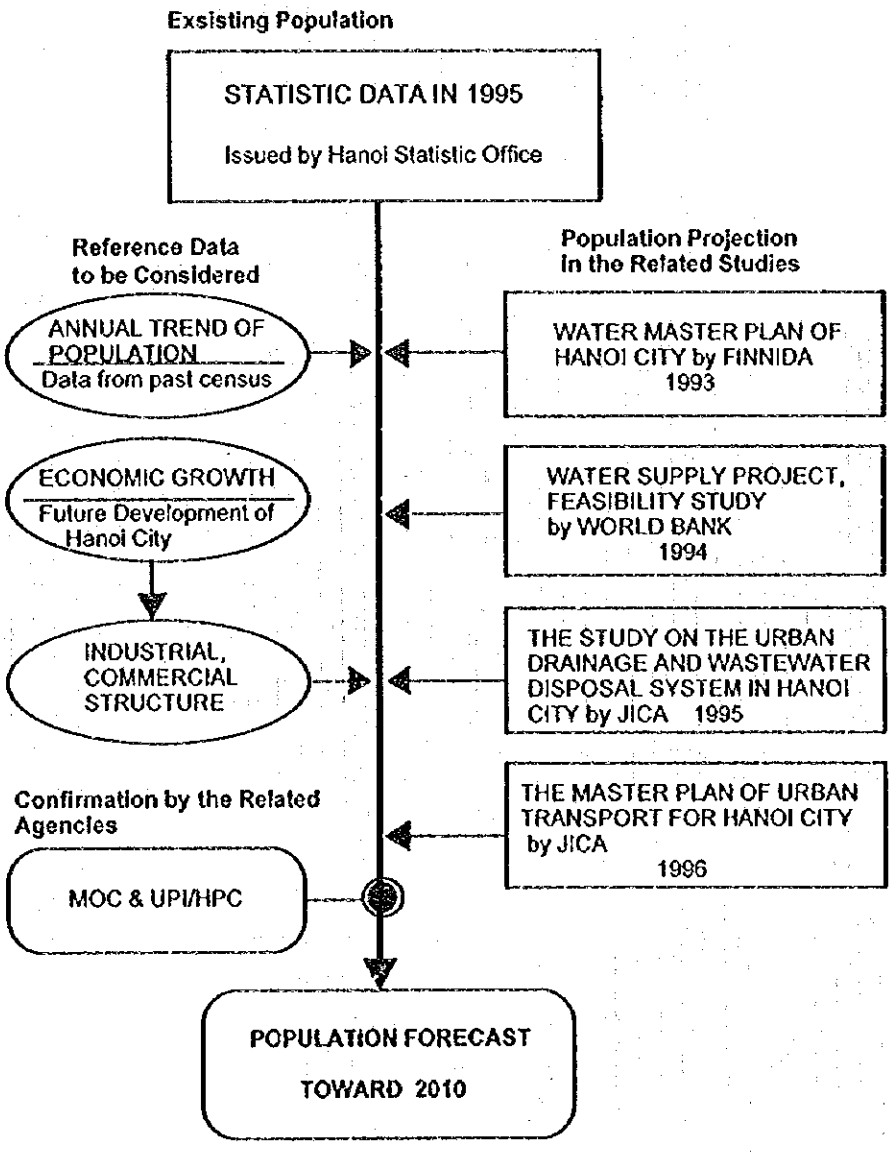


Fig.1.3-6 PROCEDURE FOR POPULATION FORECAST

(3) Population Forecast for 2010

Further breakdown of population by "District" based on the "Community" were shown in the attached table and figure.

The figure shows trends of rapid growth for suburban area comparing with urban area. Therefore, future trend of urban area is growing up slightly. Exceptionally, districts of Hoan Kiem and Hai Ba Trung are slightly going down considerably to improving of high density and policy for conservation of historical town in Hoan Kiem.

On the other hand, unregistered people could be as high as 20 to 30% of the registered population which estimated by the World Bank report. This population also must be considered for estimation of future water demand.

Average annual population growth rates are 0.24% for the urban area constantly and 4.20% up to 2000, 3.47% up to 2005, 2.95% up to 2010 for suburban area.
Therefore, average of whole Hanoi city is 2.28% up to 2000, 2.05% up to 2005 and 1.86% up to 2010.
According to the population forecast concluded under the above assumptions, the urban population will reach 1.25 million, 2.01 million for suburban and the total population of Hanoi city will reach 3.25 million in the year 2010.

According this analysis, population densities in urban area in 2010 will be high varying from 97.0 to 320.4 persons/ha by district.
Besides the suburban area there will be still low varying from 10.6 to 41.5 persons/ha by district in average.

Based on this analysis, the water supply area for the target year will be designated by density in each Commune together with considerable trends and new development.

Formulated population and its densities in each Commune is shown on the following tables and maps.

Table 1.3-3 POPULATION FORECAST : SUMMARY

District (Quan / Huyen)	Area (ha)	Present		Forecast					
		Population in 1995	Density (p/ha)	Population in 2000	Density (p/ha)	Population in 2005	Density (p/ha)	Population in 2010	Density (p/ha)
Tay Ho	1,907.8	80,638	42.3	115,451	60.5	150,265	78.8	185,075	97.0
Ba Dinh	915.8	191,286	208.9	191,848	209.5	192,411	210.1	192,968	210.7
Hoan Kiem	417.2	193,504	463.8	173,556	416.0	153,606	368.2	133,653	320.4
Dong Da	1,484.6	391,686	263.8	403,851	272.0	416,016	280.2	428,173	288.4
Hai Ba Trung	1,108.0	347,289	313.4	337,044	304.2	326,800	294.9	316,548	285.7
Total of Urban Area	5,833.4	1,204,403	206.5	1,221,750	209.4	1,239,098	212.4	1,256,417	215.4
(Growth rate per year)				(0.29%)		(0.28%)		(0.28%)	
Soc Son	31,466.9	211,186	6.7	252,349	8.0	293,511	9.3	334,667	10.6
Dong Anh	18,920.0	221,229	11.7	329,806	17.4	438,383	23.2	546,955	28.9
Gia Lam	13,810.0	302,566	21.9	364,760	26.4	426,956	30.9	489,139	35.4
Tu Liem	9,125.2	241,848	26.5	287,439	31.5	333,027	36.5	378,606	41.5
Thanh Tri	9,905.7	213,655	21.6	227,747	23.0	241,840	24.4	255,926	25.8
Total of Suburban	83,227.8	1,190,484	14.3	1,462,101	17.6	1,733,717	20.8	2,005,293	24.1
(Growth rate per year)				(4.20%)		(3.47%)		(2.95%)	
Total of Whole City	89,061.2	2,394,887	26.9	2,683,851	30.1	2,972,815	33.4	3,261,710	36.6
(Growth rate per year)				(2.30%)		(2.07%)		(1.87%)	

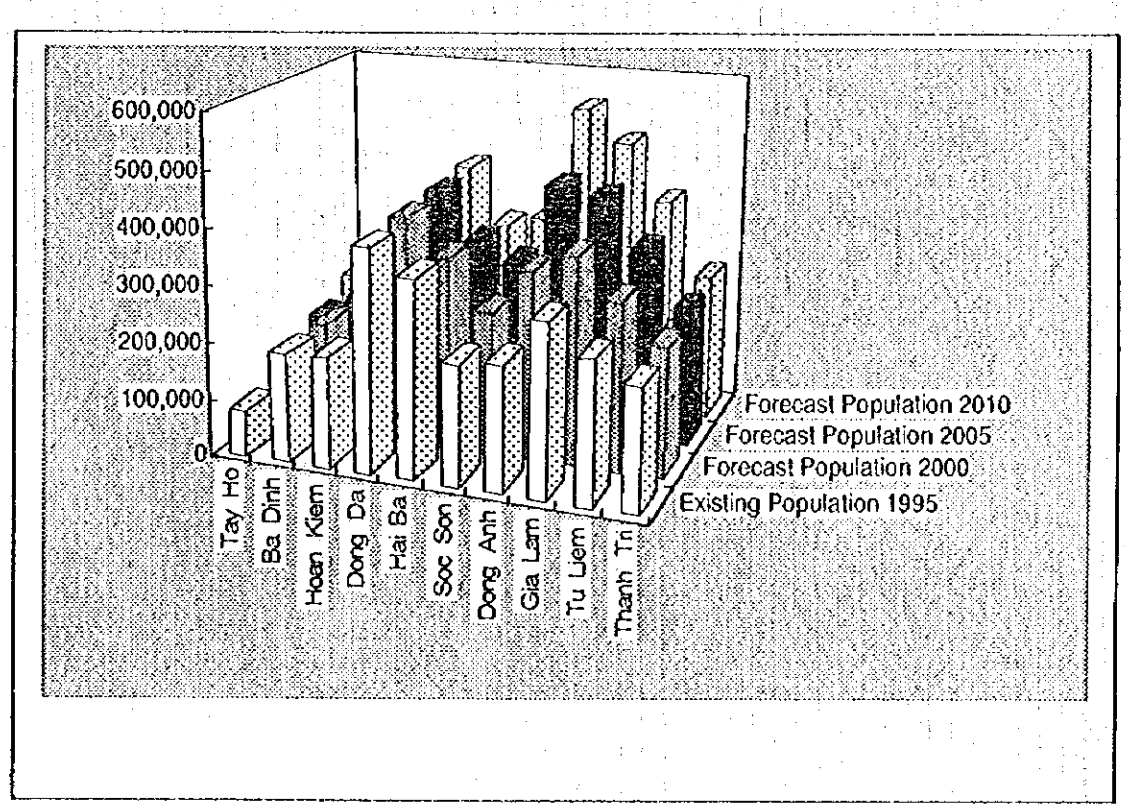


Fig.1.3-7 POPULATION GROWTH IN EACH DISTRICT BY 5 YEARS

Fig.1.3-8 POPULATION DENSITY IN URBAN AREA (Year 2010)

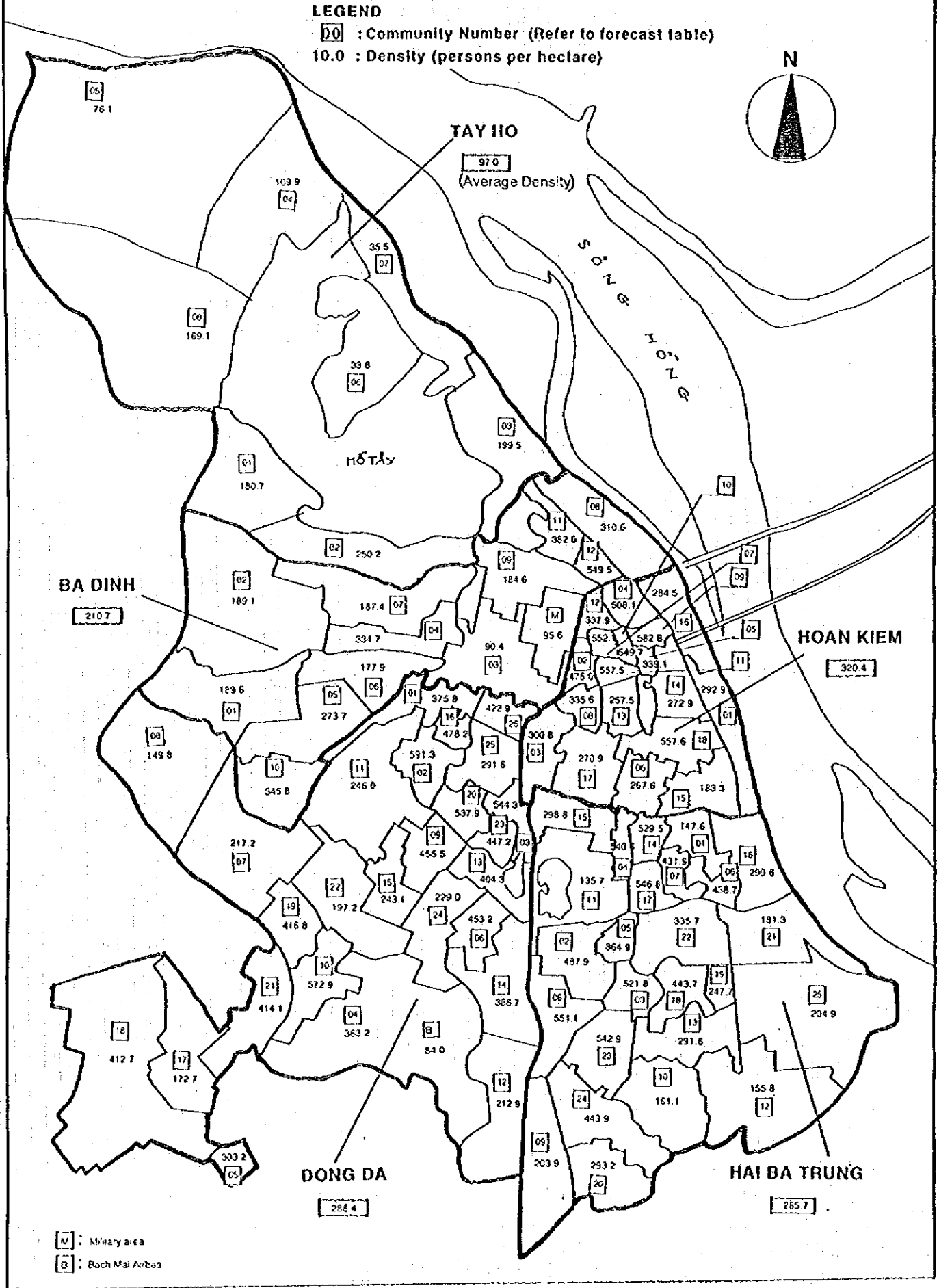


Fig.1.3-9 POPULATION IN SUBURBAN AREA (Year 2010)

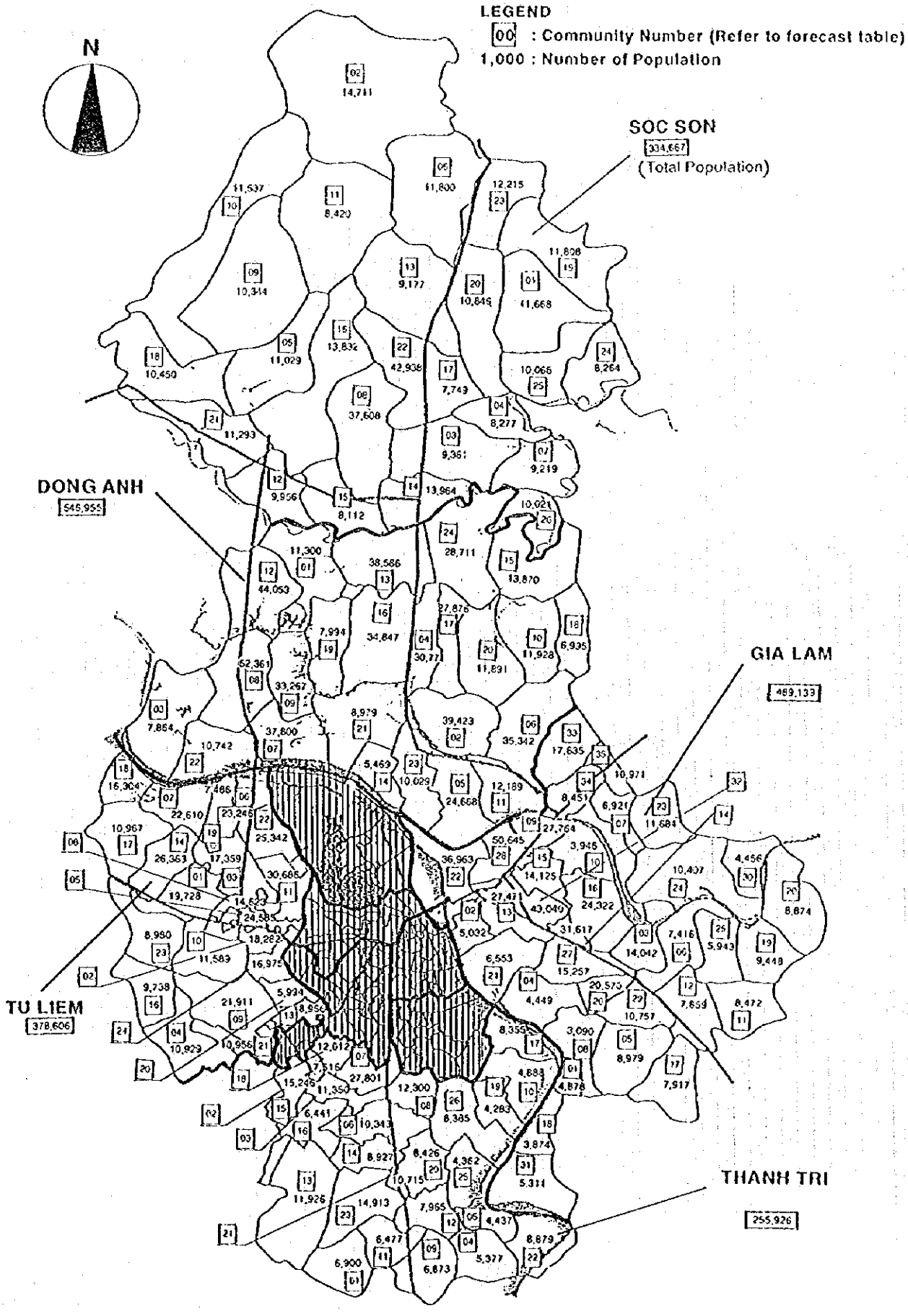
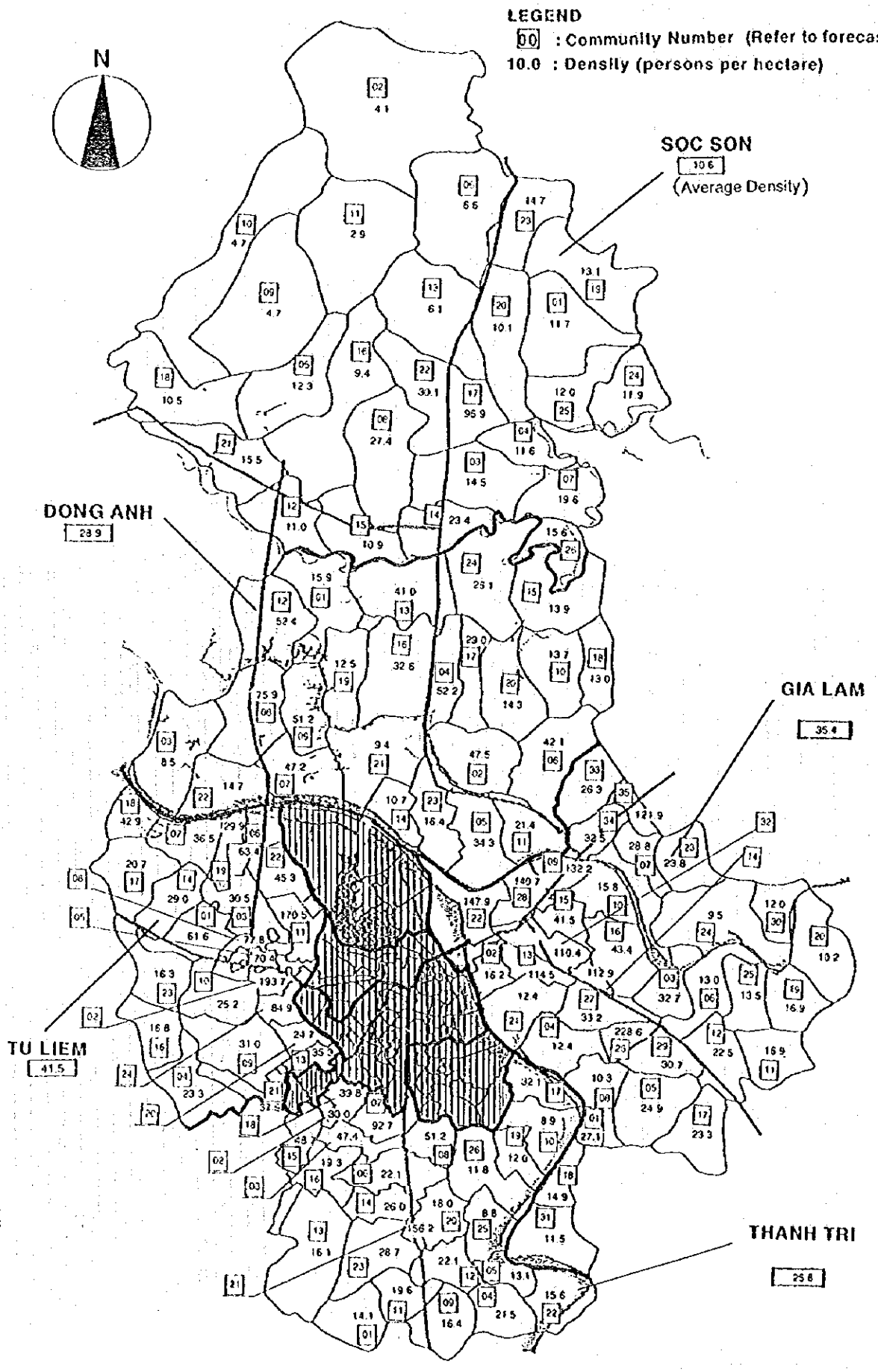


Fig.1.3-10 **POPULATION DENSITY IN SUBURBAN AREA (Year 2010)**



1.3.3 Population Served

Table 1.3-4 summarizes the population served of the year 2000, 2005 and 2010 on a basis of multiplying the future population which was forecast in urban development plan by the rate of population served. The domestic water demand is calculated on the basis of population served.

Table 1.3-4 Population Served by Group

	Group	District	Acreage (ha)	Population Served		
				2000	2005	2010
South Hanoi	U1	Urban Districts	5,833.40	1,221,750	1,239,098	1,256,417
	U1	Suburban Districts	5,121.40	214,781	242,525	270,259
	D5+D6	Tu Liem	4,126.40	106,536	128,089	149,639
	D7	Thanh Tri	2,519.40	80,446	91,596	102,743
	Total		17,600.60	1,623,513	1,701,308	1,779,058
North Hanoi	D1	Soc Son	4,124.20	66,659	89,140	111,620
	D2+D3	Dong Anh	11,330.00	238,239	344,438	450,636
	D4	Gia Lam	7,010.00	275,040	337,993	400,936
	Total		22,464.20	579,938	771,571	963,192
Rural Hanoi	R1	Soc Son	27,342.70	148,553	168,604	189,589
	R2	Dong Anh	7,590.00	73,252	77,505	81,872
	R3	Gia Lam	6,800.00	71,777	73,395	74,974
	R4	Tu Liem	1,660.00	23,241	24,229	25,232
	R5	Thanh Tri	5,603.70	67,496	68,713	69,875
	Total		48,996.40	384,319	412,446	441,542
Hanoi Total			89,061.20	2,587,770	2,885,325	3,183,792

(Note)
Population served is calculated on the basis of the population forecast and the rate of population served.

1.4 UNIT WATER DEMAND

1.4.1 Water Usage

The water usage is classified into four categories as described below:

(1) Domestic water

The domestic water is for living purpose such as for drinking, cooking, washing, bathing and sanitation.

In the case of Group R (rural area), domestic water includes non-domestic water use in small shop, school and public office, since these facilities are on a small scale and scarcely exist in the area (villages).

(2) Non-domestic water

A. Non-domestic water for Group U

Non-domestic water for Group U is classified into the following three categories based on the category of the water charge ledger of HWBC.

(a) Commercial	for commerce, private offices and foreigners
(b) State	for schools, institutes, hospitals and small industries
(c) Public	for public office, sprinkling for park/road and pipe flashing

B. Non-domestic Water for Group D

Non-domestic water for Group D is classified based on land use plan categorized as below:

(a) Schools and institutions
(b) Hospitals
(c) Small markets/restaurants, markets and shopping centers
(d) Public offices, multipurpose halls, administration offices and Libraries
(e) Miscellaneous use, sprinkling for green area/road and pipe flashing

(3) Industrial water

The industrial water includes the industrial process water, the water used for the industry-related ancillary facilities (office, warehouse, car park, sprinkling water for road) and drinking water for workers.

In order to strengthen the management of the waterworks, it is assumed that the revenue from the industrial water is an essential condition.

Water demand is forecast as a combination of the industrial water for developing project with the existing industrial water contingent on consumers' willingness to change their water sources from private wells.

(4) Fire Prevention Water

Fire prevention is an important function of waterworks. A total amount of water used in a year for extinguishing fire is a negligible part of the total water demand, but during a fire the rate of demand is so great. Therefore, the water used for fire prevention is not included in water demand forecast, but the design of fire hydrant equipment and capacity of distribution reservoir should be taken into account of fire prevention activities.

1.4.2 Present Unit Water Demand of Hanoi

The water demand estimation is one of the most important factors for planning water supply. Water consumption recording in the ledger book is one of the useful data sources.

In the existing service area, two types of water charge collecting system are practiced, namely:

(a) Water meter system — Water is provided through house connections, and water consumption is tidily recorded. The water charge is collected in accordance with the meter.

(b) Flat-rate system — Where water consumption is not recorded at all, water charge is collected by flat-rate system.

The recorded water consumption seems to have been limited by the supply capacity rather than the water demand of the consumers, since the demand exceeds the supply capacity.

In order to confirm the unit water demand, the water demand analyses in the previous studies were carefully reviewed and an interview survey was undertaken for approximately 600 samples in the study area.

1) Analysis 1: Records in Ledger of Hanoi Water Business Company (HWBC)

The water bill is based on water meters' reading. According to the past records of water bills for six months from January to June in 1996, average daily water consumption was 61,000 m3/day while the number of consumers in the records was 589,000 inhabitants. Accordingly, the water consumption rate is estimated at 104 l/c/d. Considering that the design capacity is insufficient for the water demand and the pipeline density is also insufficient for the existing facility, this(104 l/c/d) is presumably an under-estimated water consumption rate.

2) Analysis 2: Water Consumption Rate in the Previous Studies in Group U and D

There are two previous studies concerning the water consumption rate: the Feasibility Study on Hanoi Water Supply and Environment Project (HWSEP) in 1995 and the Study on Urban Drainage and Waste Water Disposal System (UDWWD) in 1995.

The study of HWSEP reports that, in the areas where water-bills are issued on a basis of meter-measured consumption, the data on domestic water use are made available on a very limited scale still now.

The early results from Kim Ma Thuong and Cong Vi areas (two pilot studies started by HWBC and HWSP in 1994) suggest that the average domestic water use in water meter households was recorded as 64 l/c/d in Cong Vi and 133 l/c/d in Kim Ma Thuong.

The consumption in Cong Vi area is about 50% lower than in Kim Ma Thoung area. It is suggested that both study areas (Cong Vi and Kim Ma Thuong) had different conditions, such as the progress of pipe renovation work, when two pilot studies were undertaken. In the case of Kim Ma Thuong area, the new main distribution network, has been completed in order to supply water with sufficient quantity and pressure. In addition to the advantageous conditions of water supply system, the living standards of the consumers in Kim Ma Thuong were higher than in Cong Vi area. For this reason, an overall average water consumption rate in the urban area was estimated at less than 133 l/c/d for the planning purpose in the study.

In UDWWD, the per capita water demand was estimated in 1992 as shown in Table 1-4-1.

Table 1-4-1 Per Capita Water Demand (by UDWWD)

(l/c/d)

Year / Type of water supply	1992	2010
Public water supply	90	180
Individual water supply	50	100

In order to estimate the domestic water demand of 1996 based on the above estimate for 1992, an assumption was made that an annual increase in the domestic water demand is at a rate of 9%. Then, the unit water demand of 1996 can be calculated as 127 l/c/d in Group U and 71 l/c/d in Group D area.

3) Analysis 3: Field Survey

A. Interview Survey

In order to draw real features of the water demand, an interview survey was undertaken for about 600 samples including households, offices, shops and other categorized consumers. Per capita water consumption surveyed by the interview is shown in percentage in Fig. 1.4-1.

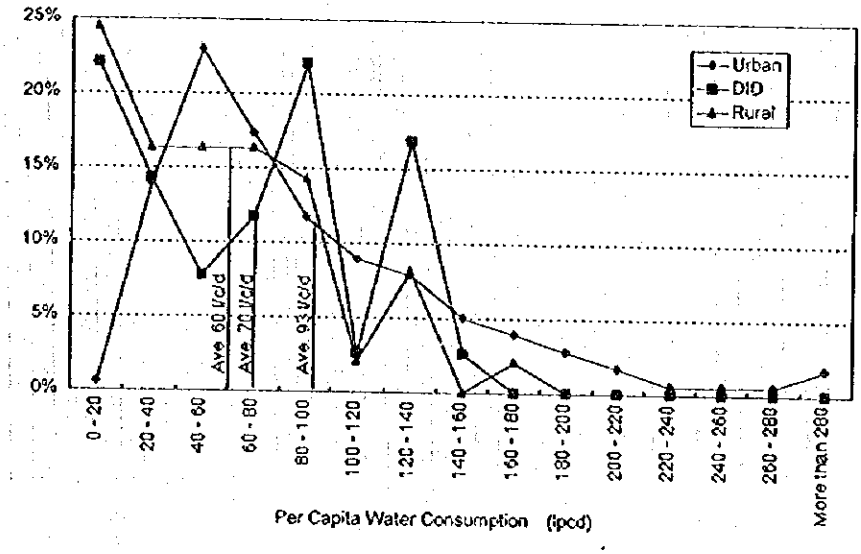


Fig. 1.4-1 Survey Result of Per Capita Water Consumption by Group

As a result of the interview survey, the per capita consumption of present domestic water consumption is summarized in Table 1.4-2

Table 1.4-2 Survey Result of Per Capita Water Consumption (1996)

(l/c/d)

Group	Per Capita Water Consumption
Group U	93
Group D	70
Group R	60

This is the present water consumption rate which may be influenced by insufficient supply capacity. For estimation of the actual domestic water demand, an analysis was made to clarify to what degree the consumers are satisfied. Fig. 1.4-2 presents a degree of satisfaction.

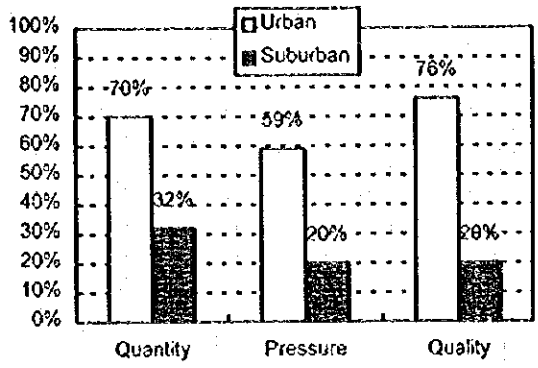


Fig. 1.4-2 Degree of Satisfaction

In the urban area (Group U) more than 70% of the consumers is satisfied with the quantity and quality of the water supplied. On the other hand, only 60% of the consumers is satisfied with the water pressure of the existing water supply system.

The consumer group who are not satisfied with the existing water supply system in Group U corresponds to the group who are consuming water less than 60 l/c/d. The rest of the consumers using water more than 60 l/c/d is assumed to be contented with the existing water supply. An average water consumption rate of this group is 120 l/c/d which is assumed to be an average present domestic water demand in Group U.

The estimation of the domestic water demand in DID (Group D) is based on the comparison of the consumer durables data between Group D and U, since the consumer durables are closely related to the water consumption. Fig. 1.4-3 shows the possession rate of consumer durables.

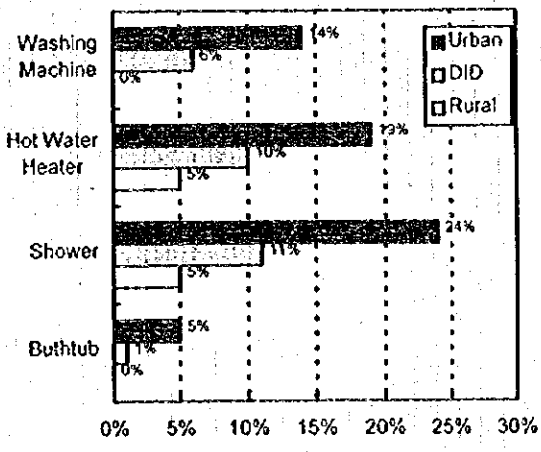


Fig. 1.4-3 Possession Rate of Consumer Durables

In Fig. 1.4-3, every possession rate of consumer durables in DID (Group D) area was about 50% lower than the urban districts (Group U). Based on the unit water consumption of urban district being 120 l/c/d, 70 l/c/d of Group D calculated by the interview survey is considered reasonable per capita water consumption.

In rural area, the possession rate of consumer durables is less than 5% in Fig. 1.4-3. It means that almost all of the consumers would use a minimum quantity of water for their living. In Fig. 1.4-1, the rate of households by area and its unit water consumption is shown as water consumption being 60 l/c/d. In the interview survey, many samples were selected from the Group R near Group D where living standard are high. In this connection, the water demand in Group R is estimated to be less than 60 l/c/d.

B. Field Survey in Two Villages

Field survey was conducted in two villages where water is provided by existing water supply system. Per capita consumption is shown as a result in Table 1.4-3.

Table 1.4-3 Per Capita Consumption in Villages

District	Village	Water Consumption
Tu Liem	Phu Dien	57 l/c/d
Tu Liem	Tay Tuu	45 l/c/d

As the result of surveys, the water demand in Group R is estimated at 50 l/c/d.

4) Present per capita water demand

In conclusion, the per capita water demand in the Study is given in Table 1.4-4. Table gives the existing data and survey results as well for comparison.

Table 1.4-4 Summary of Per Capita Water Consumption (1996)

(l/c/d)

		Group U	Group D	Group R
Existing Data	Data of water bills	more than 104	-	-
	F/S, Hanoi Water Supply and Environment Project	less than 133	-	-
	Report, The Study on Urban Drainage and Wastewater Disposal System	127	71	-
Field Survey	Interview survey	120	70	60
	Data of field survey in two villages	-	-	50
Per Capita Consumption in the Study		**120**	**70**	**50**

1.4.3 Forecast on Unit Water Demand

(1) Domestic Water

1) Group U

According to the Study on Readjustment Planning for Hanoi City (RPHC), 2020 by National Institute for Urban and Rural Planning, the water demand forecast in urban district is given in Table 1.4-5.

Table 1.4-5 Per Capita Water Demand Forecast Formulated by RPHC

Year	2000	2010	2020
Water Demand (l/c/d)	150	180	200

From the above table, the water demand in 2005 can be calculated at 165 l/c/d: the middle value of 2000 and 2005.

In the Study on Urban Drainage and Waste Water Disposal System (UDWWD), the per capita water demand has been estimated as shown in Table 1.4-6.

Table 1.4-6 Per Capita Water Demand Forecast formulated by UDWWD

Year	1992	2010
Public water supply (l/c/d)	90	180

Per capita consumption in the Asian region including ASEAN is presented in Fig. 1.4-4.

The per capita consumption in Asian cities ranges 100 l/c/d to 200 l/c/d in majority.

Based on the data of ADB, it is reliable that the water demand in the core of Hanoi is estimated at 180 l/c/d in 2010.

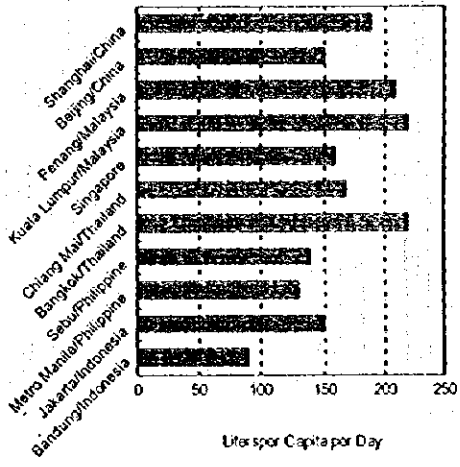


Fig. 1.4-4 Per capita Consumption in Asian Region

(Source : Water Utilities Data Book for the Asia and Pacific Region, ADB)

In conclusion, per capita water demand for Group U is summarized in Table 1.4-7.

Table 1.4-7 The Per Capita Water Demand for Group U

Year	2000	2005	2010
Water Demand (l/c/d)	150	165	180

2) Group D

The area of Group D consists of towns and new development areas.

In the towns of Group D, the per capita consumption in 2010 is estimated on a bases of the 70 l/c/d of current condition. The living condition in Group D shows a tendency to be low as compared with urban district in accordance with the interview survey, as shown in Fig. 1.4-2. Therefore, the area is estimated at 150 l/c/d in 2010, since the living condition is assumed to become urban conditions in around 2000. Meanwhile, the water demand of the development area shows the same trend as in the urban districts.

The water demand in 2010 is estimated at 150 l/c/d for towns and at 180 l/c/d for development area. The population of the towns are assumed to be approximately 50% of the total population in Group D. Based on this assumption, average water demand for the area is calculated at 165 l/c/d in 2010. The per capita demand in each year is calculated on a basis consumption will equally increase each year, as shown in Table 1.4-8.

Table 1.4-8 Water demand forecast for Group D

Year	2000	2005	2010
Existing DID (l/c/d)	90	120	150
Development area (l/c/d)	120	150	180
Group D (l/c/d)	**105**	**135**	**165**

(Note)
Based on the assumption that whole DID population consists of existing DID (50%) and development area (50%), the unit water demand of whole DID is calculated as:
[Group D (Whole DID)] = [Existing DID] x 50% + [Development area] x 50%

3) Group R

The per capita water demand in 2010 is estimated on a basis of the 50 l/c/d of current condition. The living condition in Group R still shows to be lower than in Group D. If the water demand in the areas is estimated at 90 l/c/d in 2010 as same as present water demand in Group D, it is evident that the living standards in the rural area in 2010 will become close to the present living standards in Group D.

Based on the water demand in 1996 and 2010, the per capita water demand in every 5 years is calculated on a basis of linear annual increase, as shown in Table 1.4-9.

Table 1.4-9 Water Demand Forecast based on The Living Standard

Year	1996	2000	2005	2010
Water Demand (l/c/d)	50	60	75	90

On the other hand, information of "Small Community Water Supply" issued by International Reference Center for Community Water Supply and Sanitation in 1989 shows domestic water usage data in Table 1.4-10.

Table 1.4-10 Domestic Water Use in Community Water Supply

Type of Water Supply	Typical Water Consumption (l/c/d)	Range (l/c/d)
Communal standpipe (walking distance: less than 250m)	30	20 to 50
Yard Connection (tap placed in house-yard)	40	20 to 80
House Connection (single tap)	50	30 to 60

According to the interview survey, the present water demand is 50 l/c/d in the areas.

In conclusion, the water demand in Group R is estimated at 90 l/c/d in 2010. The demand forecast is given in Table 1.4-11.

Table 1.4-11 Per Capita Water Consumption in Future

Year	2000	2005	2010
Per capita consumption (l/c/d)	**60**	**75**	**90**

4) Domestic Unit Water Demand

The aforementioned forecast on unit water demand are summarized by group in Table 1.4-12.

Table 1.4-12 Domestic Unit Water Demand Forecast by Group

(l/c/d)

	2000	2005	2010
Group U	150	165	180
Group D	105	135	165
Group R	60	75	90

(2) Non-Domestic Water

1) Group U

Fig. 1.4-5 shows the rate of water consumption by calculated on bases of the water ledger of HWBC.

Non-domestic water consumption has been compared with the whole domestic water consumption. The ratio of each category is shown in Table 1.4-13 where the whole domestic water is 100.

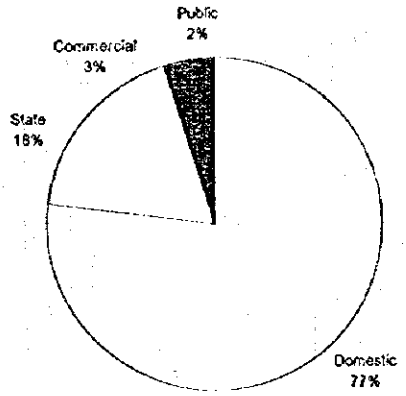


Fig. 1.4-5 The Rate of Water Consumption

Table 1.4-13 Ratio of Non-Domestic Water Use

Domestic	100	(77%)
State	24	(18%)
Commercial	4	(3%)
Public	2	(2%)

The future water demand for non-domestic use has been estimated on basis of the above comparison.

2) Group D

According to the interview survey conducted through the study, unit water demand for non-domestic purpose are shown in Table 1.4-14.

In comparison with the other data such as "the information of "Small Community Water Supply", issued by International Reference Center for Community Water Supply and Sanitation in 1989, these unit water demands are almost an approximate quantity.

Table 1.4-14 Unit Water Demand for Non-Domestic Purpose

Water usage category	Unit water demand
Schools and Institutions	13 l/c/d
Hospitals	400 l/bed/day
Small markets, Restaurants, Markets, and Shopping centers	6 l/m²/day
Public office, Multipurpose halls, Administration offices and Libraries	7 l/m²/day
Miscellaneous use, Sprinkling for green area / road and Pipe flashing	2% of domestic water use

(3) Industrial Water

The industrial water demand includes process water for production and miscellaneous water for industry-related facilities.

According to Master Plan of Industrial Development in the Hanoi Area reported by JICA in 1994, the industrial water required to each development area is as shown in Table 1.4-15.

Table 1.4-15 Required Water for Industries

Project Name	Acreage (ha.)	Required Water (m^3/day)	Unit Water Demand (m3/ha/day)
Soc Son EPZ	430	37,400	87
Dong Anh I. E.	92	3,300	36.9
Thang Long North I. E.	330	21,160	64.1
Gia Lam I. E.	528	30,000	56.8
Daewoo I. E.	80	not studied	-
Thang Long South I. E.	220	8,200	37.3
Total	1,600	100,060	62.5

In Table 1.4-15, industrial water required is to be about 63 m^3/ha/day. It seems higher consumption than other previous studies. The water demand in the report indicates outline of required water of the new industrial development plan. Therefore, the industrial water demand should be carefully reviewed.

According to the study of Soc Son EPZ implemented by FINNIDA in 1995, the total consumption is estimated at 18,600 m^3/day. Then, unit demand was calculated to at 43 m^3/ha/day.

The Study on Readjustment Planning for Hanoi City, 2020 reported by National Institute for Urban and Rural Planning gives an estimation of 45 m^3/ha./day.

According to the "Water Master Plan of Hanoi City" reported by FINNIDA, the industrial water demand has been estimated at 40 m^3/ha./day in 1995 and 35 m^3/ha/day in 2010.

Type of factories constructed by the above development projects will be auto-parts factory, electric-appliance factory and textile factory. The average demand of industrial water for these factories is estimated at 58 m³/ha/day in accordance with Study Report on Industrial Location Basic Units issued by Japan Industrial Location Center. However, this water demand appears high due to high-effective land use in Japan. It seems to be reasonable that the water demand is estimated to at 40 to 45 m³/ha./day to take the land situation in Vietnam into account.

Taking into consideration the previous data and other information, the industrial water demand is concluded to be 45 m³/ha./day.

Miscellaneous water use for ancillary facilities and their workers is estimated at 5 m³/ha/day. Basic calculations are shown as below:

30 l/c/d x 100 workers/ha/day = 3 m³/ha./day
Water demand for ancillary facilities are estimated at 3% of process water (45 m³/ha/day). It is calculated at about 2 m³/ha/day.

As a result of the calculation, the total unit industrial water demand is estimated at **50 m³/ha/day.**

1.5 WATER DEMAND FORECAST

1.5.1 Introduction

The water demand is forecast on the bases of the unit water demand and the water consumption conditions such as population, land use plan and urban development plan. The process of estimation is illustrated in Fig. 1.5-1.

1.5.2 Domestic Water Demand

The water demand forecast of domestic water is shown in Table 1.5-1.

1.5.3 Non-Domestic Water Demand

The water demand forecast of non-domestic water is shown in Table 1.5-2.

1.5.4 Industrial Water Demand

Based on the criteria of the water supply plan, the future industrial water including industrial process water and the water to be used in the ancillary facilities is estimated in the water demand forecast. The water demand required for future industrial development is based on the urban planning given in the particulars of Clause 1.3 shown in Table 1.5-3.

In addition, about 300 private wells operated by 200 factories are in use for industrial water of which the total amount of discharge is estimated at 129,000 m³/day. Such industrial water provided by private wells should be also taken into consideration to estimate the water demand, since some of these factories may change their water sources from groundwater to city water supply system in future.

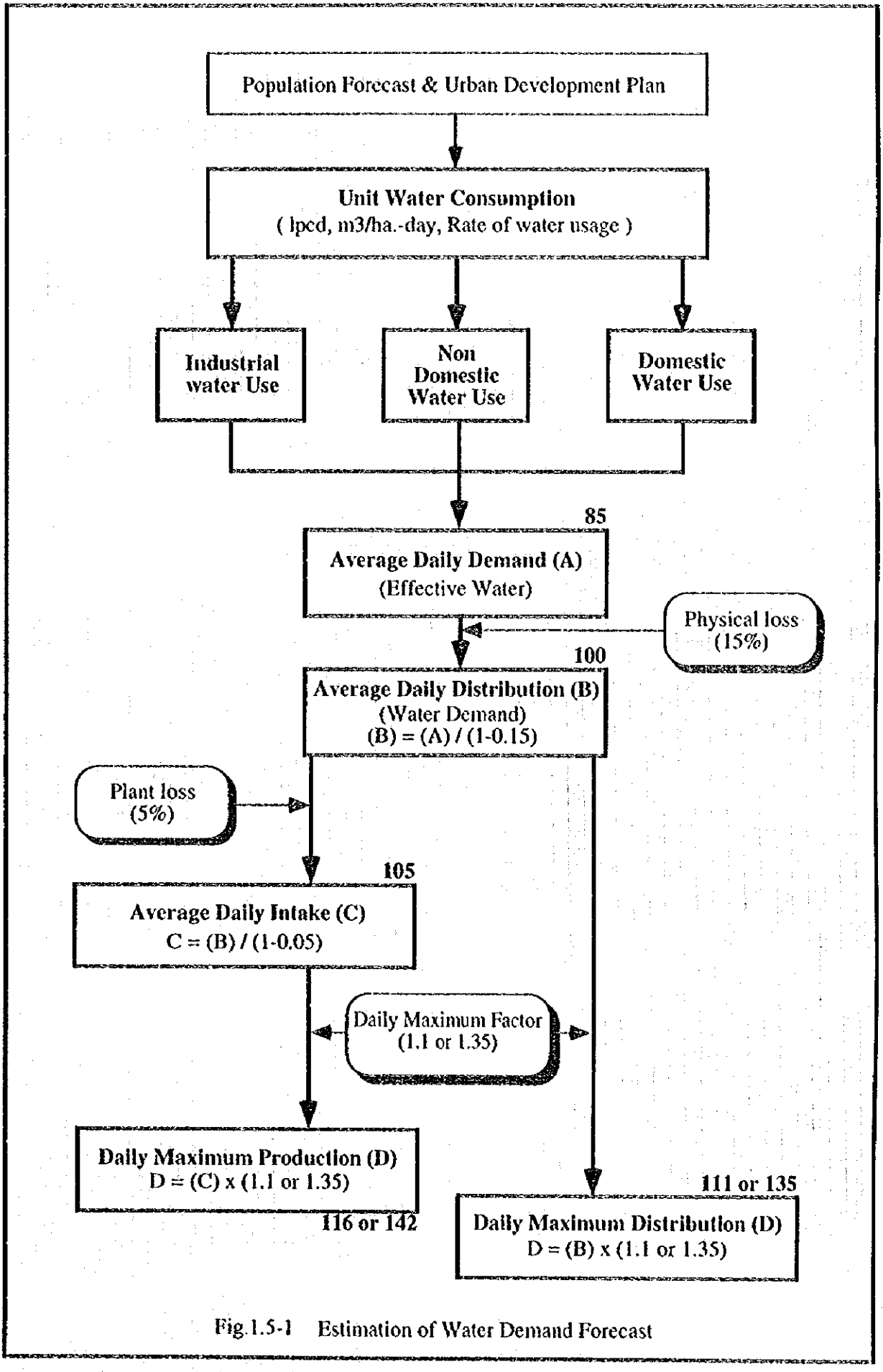


Fig.1.5-1 Estimation of Water Demand Forecast

Table 1.5-1 Domestic Water Demand Forecast

Area	District	Acreage (ha)	1995			2000			2005			2010		
			Population Served (persons)	Unit Demand (lpcd)	Average Daily Domestic Demand (m3/d)	Population Served (persons)	Unit Demand (lpcd)	Average Daily Domestic Demand (m3/d)	Population Served (persons)	Unit Demand (lpcd)	Average Daily Domestic Demand (m3/d)	Population Served (persons)	Unit Demand (lpcd)	Average Daily Domestic Demand (m3/d)
U1	Tay Ho	1,907.8	80,638	120	9,676	115,451	140	16,163	150,265	160	24,042	185,075	180	33,314
	Ba Dinh	915.8	191,286	120	22,953	191,848	140	26,860	192,411	160	30,785	192,968	180	34,734
	Hoan Kiem	417.2	193,504	120	23,222	173,556	140	24,298	153,606	160	24,576	133,653	180	24,058
	Dong Da	1,484.6	391,686	120	47,000	403,851	140	56,540	416,016	160	66,560	428,173	180	77,075
	Hai Ba Trung	1,108.0	347,289	120	41,672	337,044	140	47,184	326,800	160	52,288	316,548	180	56,976
	Tu Liem	3,338.8	128,132	120	15,375	151,851	140	21,262	175,570	160	28,092	199,282	180	35,871
	Thanh Tri	1,782.6	58,906	120	7,069	62,930	140	8,810	66,955	160	10,713	70,977	180	12,776
	Total	10,954.8	1,391,441	120	166,967	1,436,531	140	201,117	1,481,623	160	237,056	1,526,676	180	274,804
D1	Soc Son	4,124.2	44,177	70	3,093	66,659	105	6,999	89,140	135	12,033	111,620	165	18,418
D2	Donh Anh	7,620.0	93,158	70	6,521	152,910	105	16,055	212,662	135	28,711	272,413	165	44,948
D3	Donh Anh	3,710.0	38,881	70	2,721	85,329	105	8,960	131,776	135	17,790	178,223	165	29,407
D4a	Gia Lam	2,100.0	55,023	70	3,851	57,856	105	6,074	60,689	135	8,193	63,521	165	10,481
D4b	Gia Lam	4,910.0	157,068	70	10,995	217,184	105	22,803	277,304	135	37,436	337,415	165	55,674
D5	Tu Liem	1,746.4	47,733	70	3,342	56,301	105	5,911	64,868	135	8,756	73,433	165	12,116
D6	Tu Liem	2,380.0	37,248	70	2,607	50,235	105	5,275	63,221	135	8,535	76,206	165	12,574
D7	Thanh Tri	2,519.4	69,297	70	4,851	80,446	105	8,446	91,596	135	12,365	102,743	165	16,953
R1	Soc Son	27,342.7	129,430	50	6,471	148,553	60	8,912	168,604	75	12,645	189,589	90	17,063
R2a	Dong Anh	3,240.0	33,895	50	1,694	35,240	60	2,114	36,605	75	2,746	37,982	90	3,419
R2b	Dong Anh	3,430.0	29,449	50	1,472	31,938	60	1,916	34,524	75	2,589	37,206	90	3,348
R2c	Dong Anh	920.0	5,779	50	289	6,074	60	364	6,376	75	478	6,684	90	602
R3a	Gia Lam	4,400.0	41,510	50	2,076	43,240	60	2,596	44,991	75	3,374	46,765	90	4,209
R3b	Gia Lam	2,400.0	28,607	50	1,430	28,537	60	1,713	28,404	75	2,131	28,209	90	2,537
R4	Tu Liem	1,660.0	22,269	50	1,114	23,241	60	1,394	24,229	75	1,817	25,232	90	2,271
R5a	Thanh Tri	3,289.5	37,189	50	1,861	37,217	60	2,233	37,169	75	2,788	37,051	90	3,334
R5b	Thanh Tri	2,314.2	29,036	50	1,453	30,279	60	1,817	31,544	75	2,365	32,824	90	2,954
Total		89,061.2	2,291,190		222,808	2,587,770		304,699	2,885,325		401,808	3,183,792		515,112

Table 1.5-2a Non-domestic Water Demand Forecast (Group U)

District	Average Daily Domestic Water Demand (m3/d)	Commercial [4% of Domestic Water Demand] (m3/d)	State [24% of Domestic Water Demand] (m3/d)	Public Use [2% of Domestic Water Demand] (m3/d)	Total (m3/day)
Year 2000					
Tay Ho	16,163	647	3,879	323	4,849
Ba Dinh	26,860	1,074	6,446	537	8,057
Hoan Kiem	24,298	972	5,832	486	7,290
Dong Da	56,540	2,262	13,570	1,131	16,963
Hai Ba Trung	47,184	1,887	11,324	944	14,155
Tu Liem	21,262	850	5,103	425	6,378
Thanh Tri	8,810	352	2,114	176	2,642
Total	201,117	8,044	48,268	4,022	60,334
Year 2005					
Tay Ho	24,042	962	5,770	481	7,213
Ba Dinh	30,765	1,231	7,388	616	9,235
Hoan Kiem	24,576	983	5,898	492	7,373
Dong Da	66,560	2,662	15,974	1,331	19,967
Hai Ba Trung	52,288	2,092	12,549	1,046	15,687
Tu Liem	28,092	1,124	6,742	562	8,428
Thanh Tri	10,713	429	2,571	214	3,214
Total	237,056	9,483	56,892	4,742	71,117
Year 2010					
Tay Ho	33,314	1,333	7,995	666	9,994
Ba Dinh	34,734	1,389	8,336	695	10,420
Hoan Kiem	24,058	962	5,774	481	7,217
Dong Da	77,075	3,083	18,498	1,542	23,123
Hai Ba Trung	56,976	2,279	13,674	1,140	17,093
Tu Liem	35,871	1,435	8,609	717	10,761
Thanh Tri	12,776	511	3,066	256	3,833
Total	274,804	10,992	65,952	5,497	82,441

Table 1.5-2b Non-domestic Water Demand Forecast (Group D)

Area	District	Educaational Facilities [13 l/pcd]		Medical Facilities [400 l/bed/day]		Commercial Facilities [6 l/m2/day]		Public Service Facilities [7 l/m2/day]		Public Use [2% of Domestic Water Demand]		Total (m3/day)
		Number of students (persons)	Daily Average Water Demand (m3/d)	Number of beds (beds)	Daily Average Water Demand (m3/d)	Acreage (ha)	Daily Average Water Demand (m3/d)	Acreage (ha)	Daily Average Water Demand (m3/d)	Daily Average Domestic Water Demand (m3/d)	Daily Average Water Demand (m3/d)	
Year 2000												
D1	Soc Son	13,732	179	0	0	20.0	1,200	0.3	21	6,999	140	1,540
D2	Dong Anh	31,499	409	0	0	51.2	3,072	0.7	49	16,056	321	3,851
D3	Dong Anh	17,578	229	0	0	25.6	1,536	0.4	28	8,960	179	1,972
D4a	Gia Lam	11,918	155	11	4	19.4	1,162	0.3	21	6,075	122	1,464
D4b	Gia Lam	44,740	582	39	16	72.7	4,364	1.1	77	22,804	456	5,495
D5	Tu Liem	11,598	151	0	0	16.9	1,014	0.3	21	5,912	118	1,304
D6	Tu Liem	10,348	135	0	0	15.1	906	0.2	14	5,275	106	1,161
D7	Thanh Tri	16,572	215	0	0	24.1	1,446	0.4	28	8,447	169	1,858
	Total	157,985	2,055	50	20	245.0	14,700	3.7	259	80,528	1,611	18,645
Year 2005												
D1	Soc Son	17,917	233	0	0	26.7	1,602	0.4	28	12,034	241	2,104
D2	Dong Anh	42,745	556	50	20	71.2	4,272	1.1	77	28,709	574	5,499
D3	Dong Anh	26,478	344	0	0	44.1	2,646	0.6	42	17,790	356	3,388
D4a	Gia Lam	12,199	159	15	6	20.3	1,220	0.3	23	8,193	164	1,572
D4b	Gia Lam	55,738	724	70	28	92.9	5,572	1.5	103	37,436	749	7,176
D5	Tu Liem	13,038	169	0	0	19.5	1,170	0.3	21	8,757	175	1,535
D6	Tu Liem	12,707	165	0	0	19.0	1,140	0.3	21	8,535	171	1,497
D7	Thanh Tri	18,411	239	0	0	27.5	1,650	0.4	28	12,365	247	2,164
	Total	199,233	2,589	135	54	321.2	19,272	4.9	343	133,819	2,677	24,935
Year 2010												
D1	Soc Son	21,989	286	0	0	37.4	2,244	0.5	35	18,417	368	2,933
D2	Dong Anh	53,665	698	70	28	91.3	5,478	1.4	98	44,948	899	7,201
D3	Dong Anh	35,110	456	0	0	59.7	3,582	0.8	56	29,407	588	4,682
D4a	Gia Lam	12,514	163	16	6	21.3	1,277	0.3	23	10,481	210	1,679
D4b	Gia Lam	66,470	864	84	34	113.0	6,781	1.8	124	55,673	1,113	8,916
D5	Tu Liem	14,466	188	0	0	22.0	1,320	0.3	21	12,116	242	1,771
D6	Tu Liem	15,013	195	0	0	22.9	1,374	0.4	28	12,574	251	1,848
D7	Thanh Tri	20,240	263	0	0	34.4	2,064	0.5	35	16,953	339	2,701
	Total	239,467	3,113	170	68	402.0	24,120	6.0	420	200,569	4,010	31,731

Table 1.5-3 Industrial Water Demand for Development Plan

(Unit water consumption: 50 m³/ha/day)

Year		2000		2005		2010	
Group and District	Project Name	Area (ha.)	Water Demand (m³/day)	Area (ha.)	Water Demand (m³/day)	Area (ha.)	Water Demand (m³/day)
North Hanoi							
D1 (Soc Son)	Soc Son E. P. Z.	100	5,000	300	15,000	430	21,500
D2 (Dong Anh)	Dong Anh I. E.			92	4,600	92	4,600
D3 (Dong Anh)	Thang Long North	330	16,500	330	16,500	330	16,500
D4 (Gia Lam)	Gia Lam I. E.	367	18,350	528	26,400	528	26,400
D4 (Gia Lam)	Daewoo I. E.	80	4,000	80	4,000	80	4,000
North Hanoi Total		877	43,850	1,330	66,500	1,460	73,000
South Hanoi							
D5 (Tu Liem)	Thang Long South					220	11,000
Total		877	43,850	1,330	66,500	1,680	84,000

In addition, the current industrial water sources are the private wells maintained by the industries themselves. In order to identify the future trend of existing industrial water, the interview has been carried out to about 20 factories in respect to the degree of willingness to change water source to city water.

Based on the degree of willingness in the interview survey, the water demand forecast to change water sources to city water is estimated, as shown in Table 1.5-4.

Table1.5-4 Industrial Water Demand Due to Willingness

Group	Year district	2000 (m³/day)	2005 (m³/day)	2010 (m³/day)
D1	Soc Son	1,800	2,100	2,200
D2	Dong Anh	3,000	3,300	3,600
D4	Gia Lam	3,700	4,400	4,900
U1, D6	Urban Districts	29,500	33,200	36,300
	Total	38,000	43,000	47,000

The Industrial water demand forecast is calculated with Table 1.5-3 and 1.5-4 being put together as summarized in Table 1.5-5.

Table 1.5-5 Industrial Water Demand Forecast

(m3/d)

	2000	2005	2010
North Hanoi			
D1 (Soc Son)	6,800	17,100	23,700
D2 (Dong Anh)	3,000	9,000	9,500
D3 (Dong Anh)	16,500	16,500	16,500
D4 (Gia Lam)	26,050	34,800	35,300
Sub Total	52,350	77,400	85,000
South Hanoi			
D5 (Tu Liem)			11,000
U1 and D6	29,500	33,200	36,300
Sub Total	29,500	33,200	47,300
Total	81,850	110,600	121,300

1.5.5 Water Demand Forecast

(1) The Average Daily Demand forecast (Effective Water)

The Average Daily Demand is formulated to summarize every category of the required water as shown Table 1.5-6.

Table 1.5-6 Average Daily Water Demand (Summary)

(m3/day)

	South Hanoi	North Hanoi	Rural Area	Total
Year 2000				
Domestic	220,749	60,891	23,059	304,699
Non-Domestic	64,657	14,322	0	78,979
Industrial	29,500	52,350	0	81,850
Total	314,906	127,563	23,059	465,528
Year 2005				
Domestic	266,712	104,163	30,933	401,808
Non-Domestic	76,313	19,739	0	96,052
Industrial	33,200	76,300	0	109,500
Total	376,225	200,202	30,933	607,360
Year 2010				
Domestic	316,447	158,928	39,737	515,112
Non-Domestic	88,761	25,411	0	114,172
Industrial	47,300	83,700	0	131,000
Total	452,508	268,039	39,737	760,284

(2) Average Daily Distribution water (Water Demand)

For determination of the Average Daily Distribution, a physical loss should be included. Based on formulation of the design criteria, the rate of physical loss is determined to be a 15 % and its formulation is shown as below:

$$w1/(1-r) = w2$$

where,

w1: Average Daily Water Demand (effective water)

r: physical loss (0.15)

w2: Average Daily Water Distribution (water demand)

In the case of existing facilities, for Master Plan's formulation, actual physical loss in the existing water supply system must be taken into consideration. It is because the physical loss was considered as 15% evenly in Average Daily Distribution water, although the existing facility's physical loss is as 25% on average.

On a basis that a renovation-plan is proposed for replacing the outdated distribution pipes, the actual physical loss will be lessened, as shown in the Table 1.5-7.

Table 1.5-7 Proposed improvement of the loss

Year	1996	2000	2005	2010
Physical loss (%)	25.0	21.0	16.0	15.0

If and when the physical loss would decrease in the existing facilities, as a matter of course, the water distribution capacity would increase, and thereby, on the contrary, Master Plan's formulated Water Distribution will decrease that much.

Fig. 1.5-2 shows this description in a visible way.

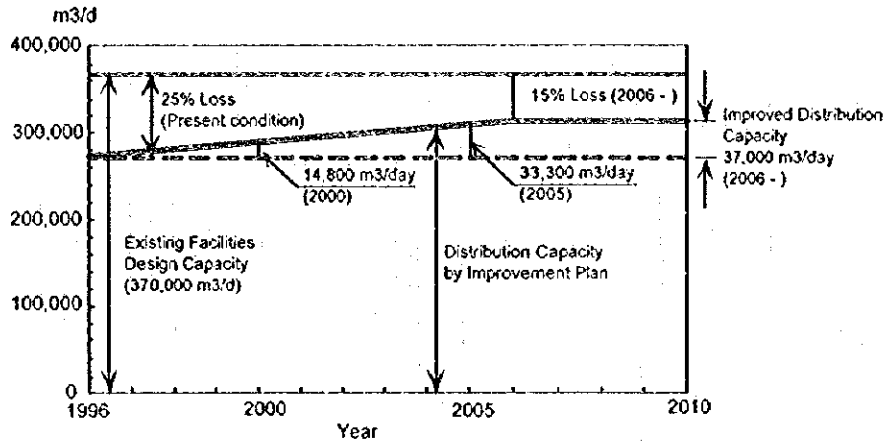


Fig. 1.5-2 Improved Distribution Water for The Existing Facilities

According to Fig. 1.5-2, Average Distribution water will be saved by 10 % with about 37,000 m³/day of distribution water of existing facilities from 2006 onward. Therefore, the distribution water from the existing facilities in Fig. 1.5-3 to 1.5-6 denotes the water capacity based on the improvement plan to lessen the loss.

The water to be consumed in treatment plant is defined as a plant loss, which is to make up a 5% of the total treated water in accordance with the design criteria. And then, the water capacity with the plant loss included in is determined to be Average Daily Intake water, as shown in Table 1.5-8. A water source is studied on a basis of Average Daily Intake water.

(3) Daily Maximum Production and Distribution

Meanwhile, from the design criteria, a peak factor is given as 1.35 in accordance with the design criteria. Therefore, the water capacity multiplied by the peak factor comes to Daily Maximum Production and Distribution water.

As the result of the calculation, The Average Daily Distribution and the Daily Maximum Distribution water forecast every five years is summarized in Table 1.5-9.

The forecast trend-curve is shown in Fig. 1.5-3 to 1.5-6.

Table 1.5-8 Average Daily Water Distribution Capacity Forecast

(m3/day)

1995

Area	District	Demand Total	Distribution Capacity [Leakage Loss : 15%]
U1	Urban	217,057	255,361
D1	Soc Son	4,021	4,731
D2	Donh Anh	8,477	9,973
D3	Donh Anh	3,537	4,161
D4a	Gia Lam	5,006	5,890
D4b	Gia Lam	14,294	16,816
D5	Tu Liem	4,345	5,112
D6	Tu Liem	3,389	3,987
D7	Thanh Tri	6,306	7,419
R1	Soc Son	6,471	7,613
R2a	Dong Anh	1,694	1,993
R2b	Dong Anh	1,472	1,732
R2c	Dong Anh	289	340
R3a	Gia Lam	2,076	2,442
R3b	Gia Lam	1,430	1,682
R4	Tu Liem	1,114	1,311
R5a	Thanh Tri	1,861	2,189
R5b	Thanh Tri	1,453	1,709
Total		284,292	334,461

2000

Area	District	(A) Domestic Water	(B) Non-domestic Water	(C) Industrial Water for Development Project	(D) Industrial Water due to Disuse of the Private Wells	(E) Demand Total [(A) + (B) + (C) + (D)]	(F) Distribution Capacity [Leakage Loss : 15%]
U1	Urban	201,117	60,334	0	29,500	290,951	342,295
D1	Soc Son	6,999	1,540	5,000	1,800	15,339	18,046
D2	Donh Anh	16,055	3,851	0	3,000	22,906	26,948
D3	Donh Anh	8,960	1,972	16,500	0	27,432	32,273
D4a	Gia Lam	6,074	1,464	0	0	7,538	8,868
D4b	Gia Lam	22,803	5,495	22,350	3,700	54,348	63,939
D5	Tu Liem	5,911	1,304	0	0	7,215	8,488
D6	Tu Liem	5,275	1,161	0	0	6,436	7,572
D7	Thanh Tri	8,446	1,858	0	0	10,304	12,122
R1	Soc Son	8,912	0	0	0	8,912	10,485
R2a	Dong Anh	2,114	0	0	0	2,114	2,487
R2b	Dong Anh	1,916	0	0	0	1,916	2,254
R2c	Dong Anh	364	0	0	0	364	428
R3a	Gia Lam	2,596	0	0	0	2,596	3,054
R3b	Gia Lam	1,713	0	0	0	1,713	2,015
R4	Tu Liem	1,394	0	0	0	1,394	1,640
R5a	Thanh Tri	2,233	0	0	0	2,233	2,627
R5b	Thanh Tri	1,817	0	0	0	1,817	2,138
Total		304,699	78,979	43,850	38,000	465,528	547,679

2005

Area	District	(A) Domestic Water	(B) Non-domestic Water	(C) Industrial Water for Development Project	(D) Industrial Water due to Disuse of the Private Wells	(E) Demand Total [(A) + (B) + (C) + (D)]	(F) Distribution Capacity [Leakage Loss : 15%]
U1	Urban	237,056	71,117	0	33,200	341,373	401,615
D1	Soc Son	12,033	2,104	15,000	2,100	31,237	36,749
D2	Donh Anh	28,711	5,499	4,600	3,300	42,110	49,541
D3	Donh Anh	17,790	3,388	16,500	0	37,678	44,327
D4a	Gia Lam	8,193	1,572	0	0	9,765	11,488
D4b	Gia Lam	37,436	7,176	30,400	4,400	79,412	93,426
D5	Tu Liem	8,756	1,535	0	0	10,291	12,107
D6	Tu Liem	8,535	1,497	0	0	10,032	11,802
D7	Thanh Tri	12,365	2,164	0	0	14,529	17,093
R1	Soc Son	12,645	0	0	0	12,645	14,876
R2a	Dong Anh	2,746	0	0	0	2,746	3,231
R2b	Dong Anh	2,589	0	0	0	2,589	3,046
R2c	Dong Anh	478	0	0	0	478	562
R3a	Gia Lam	3,374	0	0	0	3,374	3,969
R3b	Gia Lam	2,131	0	0	0	2,131	2,507
R4	Tu Liem	1,817	0	0	0	1,817	2,138
R5a	Thanh Tri	2,788	0	0	0	2,788	3,280
R5b	Thanh Tri	2,365	0	0	0	2,365	2,782
Total		401,808	96,052	66,500	43,000	607,360	714,539

2010

Area	District	(A) Domestic Water	(B) Non-domestic Water	(C) Industrial Water for Development Project	(D) Industrial Water due to Disuse of the Private Wells	(E) Demand Total [(A) + (B) + (C) + (D)]	(F) Distribution Capacity [Leakage Loss : 15%]
U1	Urban	274,804	82,441	0	36,300	393,545	462,994
D1	Soc Son	18,418	2,933	21,500	2,200	45,051	53,001
D2	Donh Anh	44,948	7,201	4,600	3,600	60,349	70,999
D3	Donh Anh	29,407	4,682	16,500	0	50,589	59,516
D4a	Gia Lam	10,481	1,679	0	0	12,160	14,306
D4b	Gia Lam	55,674	8,916	30,400	4,900	99,890	117,518
D5	Tu Liem	12,116	1,771	11,000	0	24,887	29,279
D6	Tu Liem	12,574	1,848	0	0	14,422	16,967
D7	Thanh Tri	16,953	2,701	0	0	19,654	23,122
R1	Soc Son	17,063	0	0	0	17,063	20,074
R2a	Dong Anh	3,419	0	0	0	3,419	4,022
R2b	Dong Anh	3,348	0	0	0	3,348	3,939
R2c	Dong Anh	602	0	0	0	602	708
R3a	Gia Lam	4,209	0	0	0	4,209	4,952
R3b	Gia Lam	2,537	0	0	0	2,537	2,985
R4	Tu Liem	2,271	0	0	0	2,271	2,672
R5a	Thanh Tri	3,334	0	0	0	3,334	3,922
R5b	Thanh Tri	2,954	0	0	0	2,954	3,475
Total		515,112	114,172	84,000	47,000	760,284	894,451

Table 1.5-9 Daily Maximum Water Distribution Capacity Forecast

(m3/day)

1995

Area	District	(R) Daily Maximum Distribution Capacity Total	(S) Daily Maximum Raw Water Intake and Treatment Capacity [Plant loss : 5%]
U1	Urban	344,737	361,974
D1	Soc Son	6,387	6,706
D2	Donh Anh	13,464	14,137
D3	Donh Anh	5,617	5,898
D4a	Gia Lam	7,952	8,350
D4b	Gia Lam	22,702	23,837
D5	Tu Liem	6,901	7,246
D6	Tu Liem	5,382	5,651
D7	Thanh Tri	10,016	10,517
R1	Soc Son	10,278	10,792
R2a	Dong Anh	2,691	2,826
R2b	Dong Anh	2,338	2,455
R2c	Dong Anh	459	482
R3a	Gia Lam	3,297	3,462
R3b	Gia Lam	2,271	2,385
R4	Tu Liem	1,770	1,859
R5a	Thanh Tri	2,955	3,103
R5b	Thanh Tri	2,307	2,422
Total		451,524	474,102

2000

Area	District	Domestic and Non-domestic (P) Average Daily Distribution Capacity	Domestic and Non-domestic (Q) Daily Maximum Distribution Capacity	Industrial (P') Average Daily Distribution Capacity	Industrial (Q') Daily Maximum Distribution Capacity	(R) Daily Maximum Distribution Capacity Total [(Q) + (Q')]	(S) Daily Maximum Raw Water Intake and Treatment Capacity [Plant loss : 5%]
U1	Urban	307,589	415,245	34,706	38,177	453,422	476,093
D1	Soc Son	10,046	13,562	8,000	8,800	22,362	23,480
D2	Donh Anh	23,419	31,616	3,529	3,882	35,498	37,273
D3	Donh Anh	12,861	17,362	19,412	21,353	38,715	40,651
D4a	Gia Lam	8,868	11,972	0	0	11,972	12,571
D4b	Gia Lam	33,292	44,944	30,647	33,712	78,656	82,589
D5	Tu Liem	8,488	11,459	0	0	11,459	12,032
D6	Tu Liem	7,572	10,222	0	0	10,222	10,733
D7	Thanh Tri	12,122	16,365	0	0	16,365	17,183
R1	Soc Son	10,485	14,155	0	0	14,155	14,863
R2a	Dong Anh	2,487	3,357	0	0	3,357	3,525
R2b	Dong Anh	2,254	3,043	0	0	3,043	3,195
R2c	Dong Anh	428	578	0	0	578	607
R3a	Gia Lam	3,054	4,123	0	0	4,123	4,329
R3b	Gia Lam	2,015	2,720	0	0	2,720	2,856
R4	Tu Liem	1,640	2,214	0	0	2,214	2,325
R5a	Thanh Tri	2,627	3,546	0	0	3,546	3,723
R5b	Thanh Tri	2,138	2,886	0	0	2,886	3,030
Total		451,385	609,369	98,294	105,924	715,293	751,058

2005

Area	District	Domestic and Non-domestic (P) Average Daily Distribution Capacity	Domestic and Non-domestic (Q) Daily Maximum Distribution Capacity	Industrial (P') Average Daily Distribution Capacity	Industrial (Q') Daily Maximum Distribution Capacity	(R) Daily Maximum Distribution Capacity Total [(Q) + (Q')]	(S) Daily Maximum Raw Water Intake and Treatment Capacity [Plant loss : 5%]
U1	Urban	362,556	489,451	39,059	42,965	532,416	559,037
D1	Soc Son	16,632	22,453	20,118	22,130	44,583	46,812
D2	Donh Anh	40,247	54,333	9,294	10,223	64,556	67,784
D3	Donh Anh	24,915	33,635	19,412	21,353	54,988	57,737
D4a	Gia Lam	11,488	15,509	0	0	15,509	16,284
D4b	Gia Lam	52,485	70,855	40,941	45,035	115,890	121,685
D5	Tu Liem	12,107	16,344	0	0	16,344	17,161
D6	Tu Liem	11,802	15,933	0	0	15,933	16,730
D7	Thanh Tri	17,093	23,076	0	0	23,076	24,230
R1	Soc Son	14,876	20,083	0	0	20,083	21,087
R2a	Dong Anh	3,231	4,362	0	0	4,362	4,580
R2b	Dong Anh	3,046	4,112	0	0	4,112	4,318
R2c	Dong Anh	562	759	0	0	759	797
R3a	Gia Lam	3,969	5,358	0	0	5,358	5,628
R3b	Gia Lam	2,507	3,384	0	0	3,384	3,553
R4	Tu Liem	2,138	2,886	0	0	2,886	3,030
R5a	Thanh Tri	3,280	4,428	0	0	4,428	4,649
R5b	Thanh Tri	2,782	3,756	0	0	3,756	3,944
Total		585,716	790,717	128,824	141,706	932,423	979,044

2010

Area	District	Domestic and Non-domestic (P) Average Daily Distribution Capacity	Domestic and Non-domestic (Q) Daily Maximum Distribution Capacity	Industrial (P') Average Daily Distribution Capacity	Industrial (Q') Daily Maximum Distribution Capacity	(R) Daily Maximum Distribution Capacity Total [(Q) + (Q')]	(S) Daily Maximum Raw Water Intake and Treatment Capacity [Plant loss : 5%]
U1	Urban	420,288	567,389	42,706	46,977	614,366	645,084
D1	Soc Son	25,119	33,911	27,882	30,670	64,581	67,810
D2	Donh Anh	61,352	82,825	9,647	10,612	93,437	98,109
D3	Donh Anh	40,105	54,142	19,412	21,353	75,495	79,270
D4a	Gia Lam	14,306	19,313	0	0	19,313	20,279
D4b	Gia Lam	75,988	102,584	41,529	45,682	148,266	155,679
D5	Tu Liem	16,338	22,056	12,941	14,235	36,291	38,106
D6	Tu Liem	16,967	22,905	0	0	22,905	24,050
D7	Thanh Tri	23,122	31,215	0	0	31,215	32,776
R1	Soc Son	20,074	27,100	0	0	27,100	28,455
R2a	Dong Anh	4,022	5,430	0	0	5,430	5,702
R2b	Dong Anh	3,939	5,318	0	0	5,318	5,584
R2c	Dong Anh	708	956	0	0	956	1,004
R3a	Gia Lam	4,952	6,685	0	0	6,685	7,019
R3b	Gia Lam	2,985	4,030	0	0	4,030	4,232
R4	Tu Liem	2,672	3,607	0	0	3,607	3,787
R5a	Thanh Tri	3,922	5,295	0	0	5,295	5,560
R5b	Thanh Tri	3,475	4,691	0	0	4,691	4,926
Total		740,334	999,452	154,117	169,529	1,168,981	1,227,432

Remarks :
(E) = (A) + (B) + (C) + (D)
(F) = (E) / 0.85 [Leakage Loss : 15%]
(Q) = (P) x 1.35 [Peak Day Factor : 1.35]
(Q') = (P') x 1.10 [Peak Day Factor : 1.1]
(R) = (Q) + (Q')
(S) = (R) x 1.05 [Plant Loss : 5%]

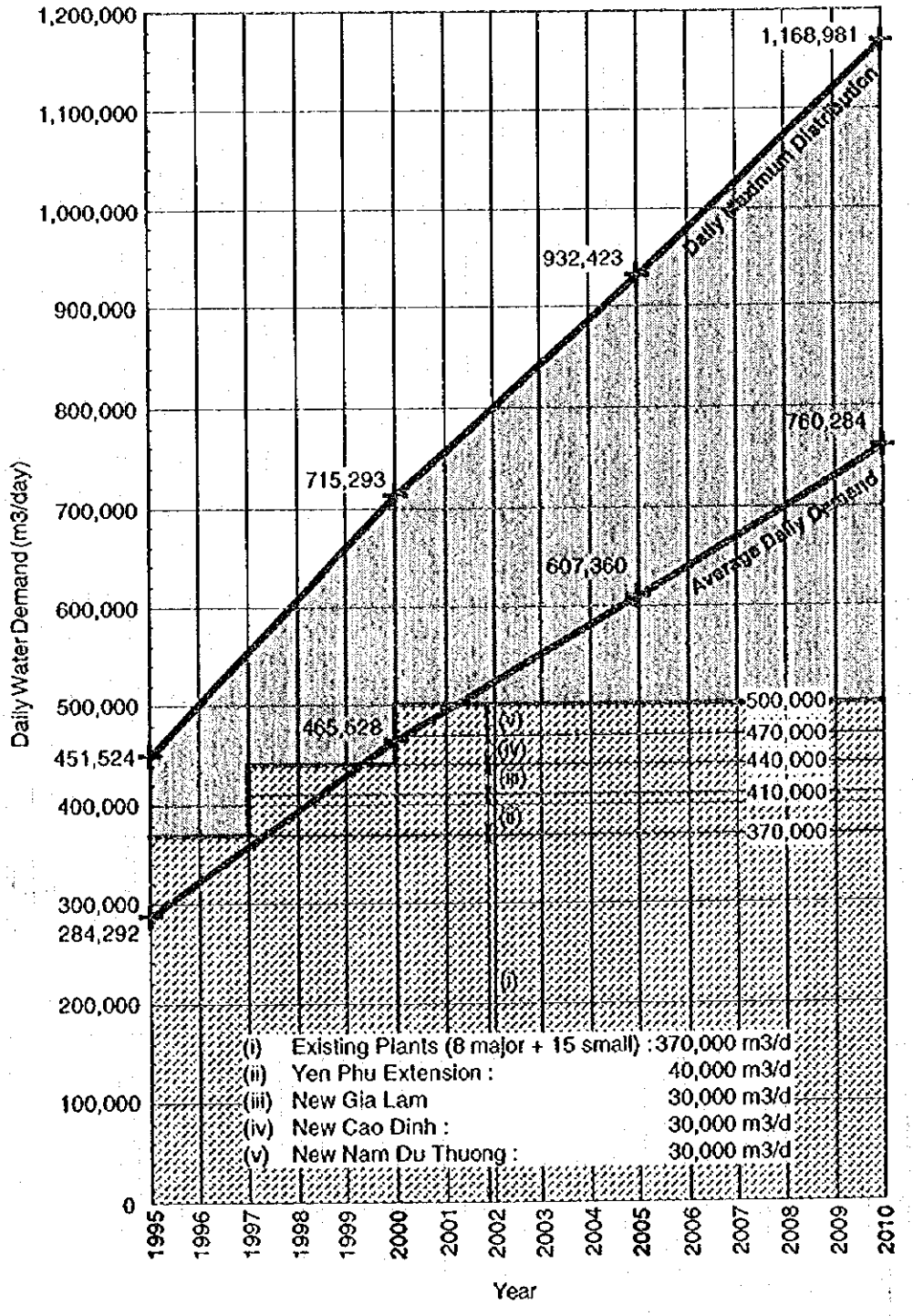


Fig. 1.5-3 Water Demand Forecast
(Whole Hanoi City)

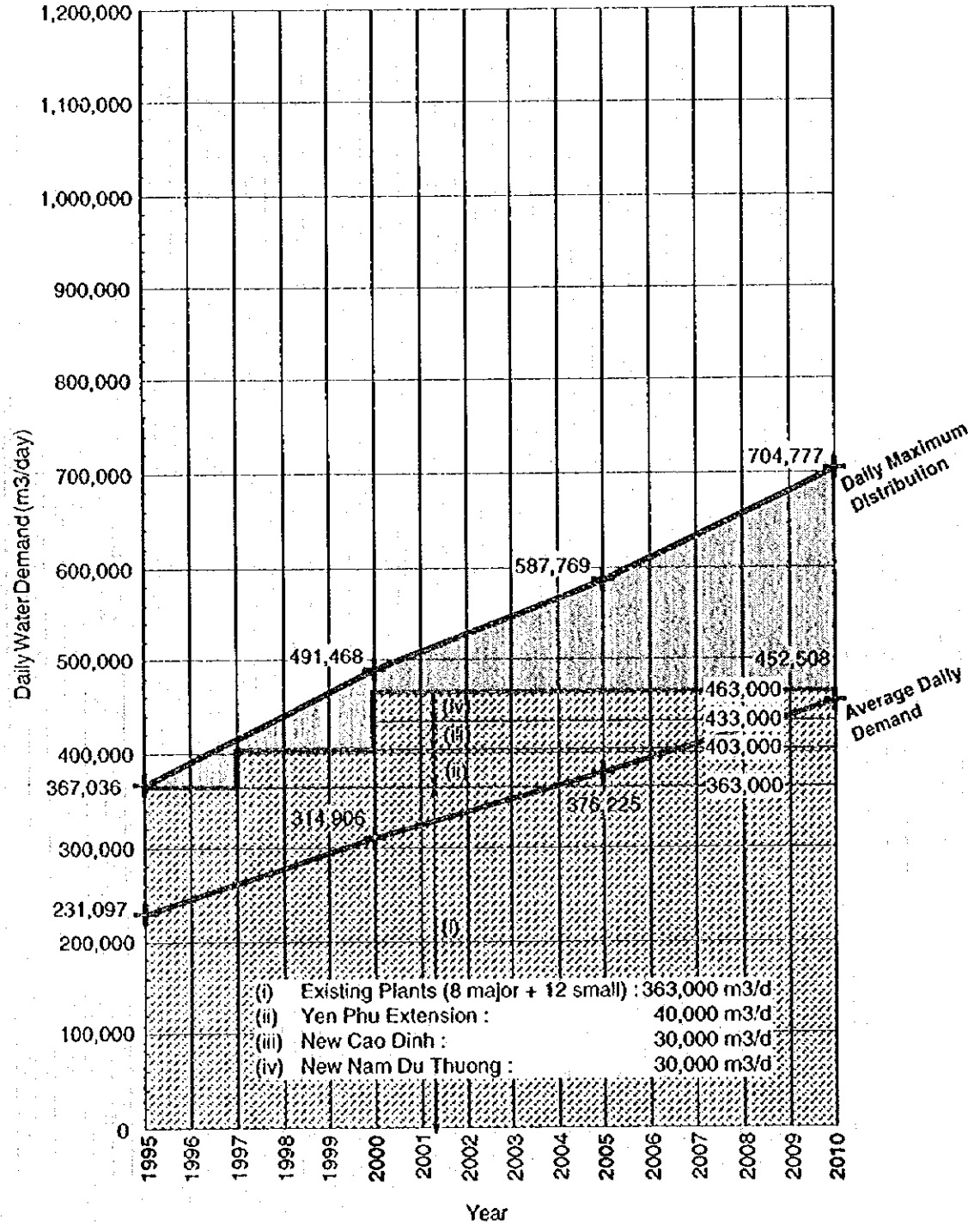


Fig. 1.5-4 Water Distribution Forecast South Hanoi

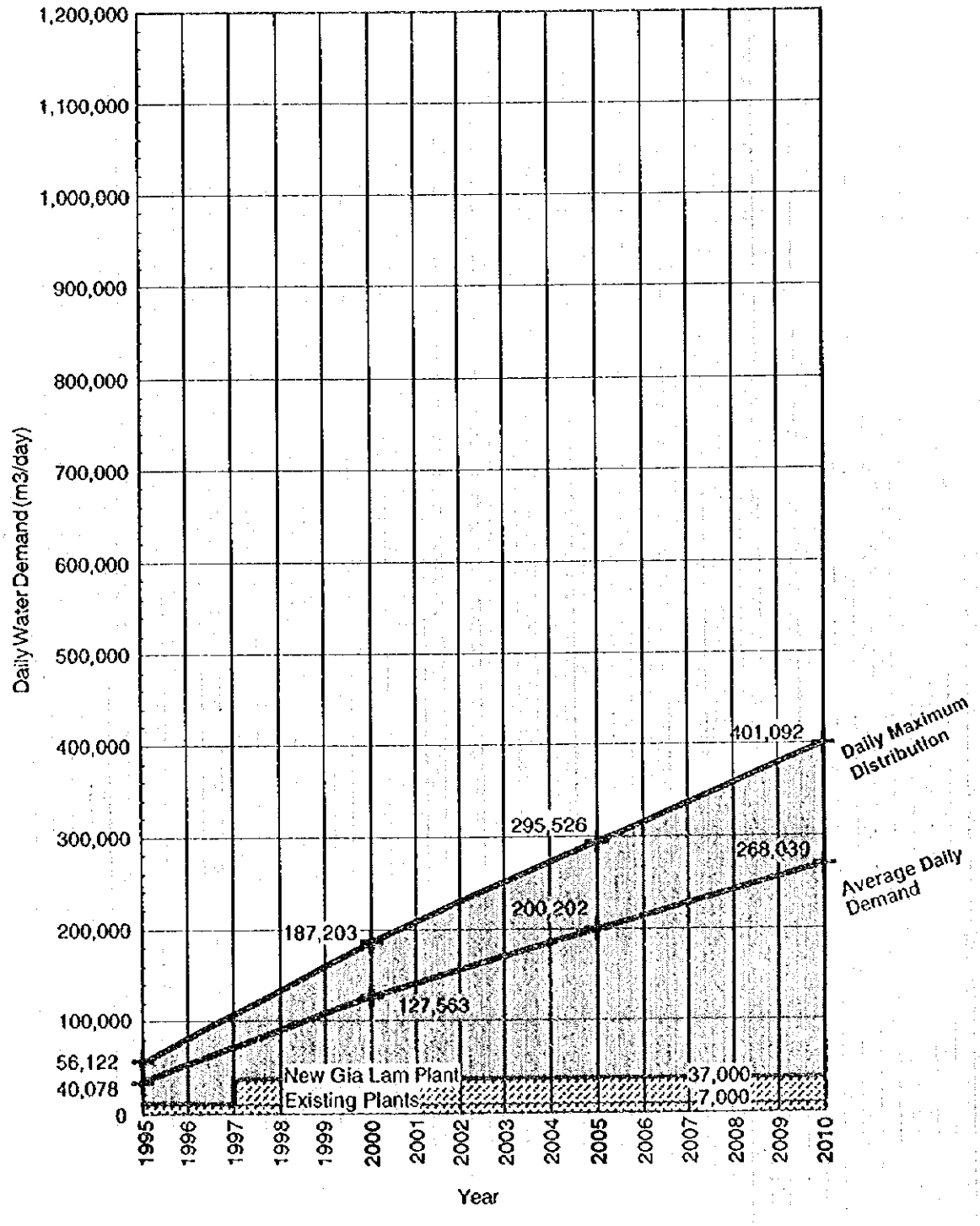


Fig. 1.5-5 Water Distribution Forecast North Hanoi

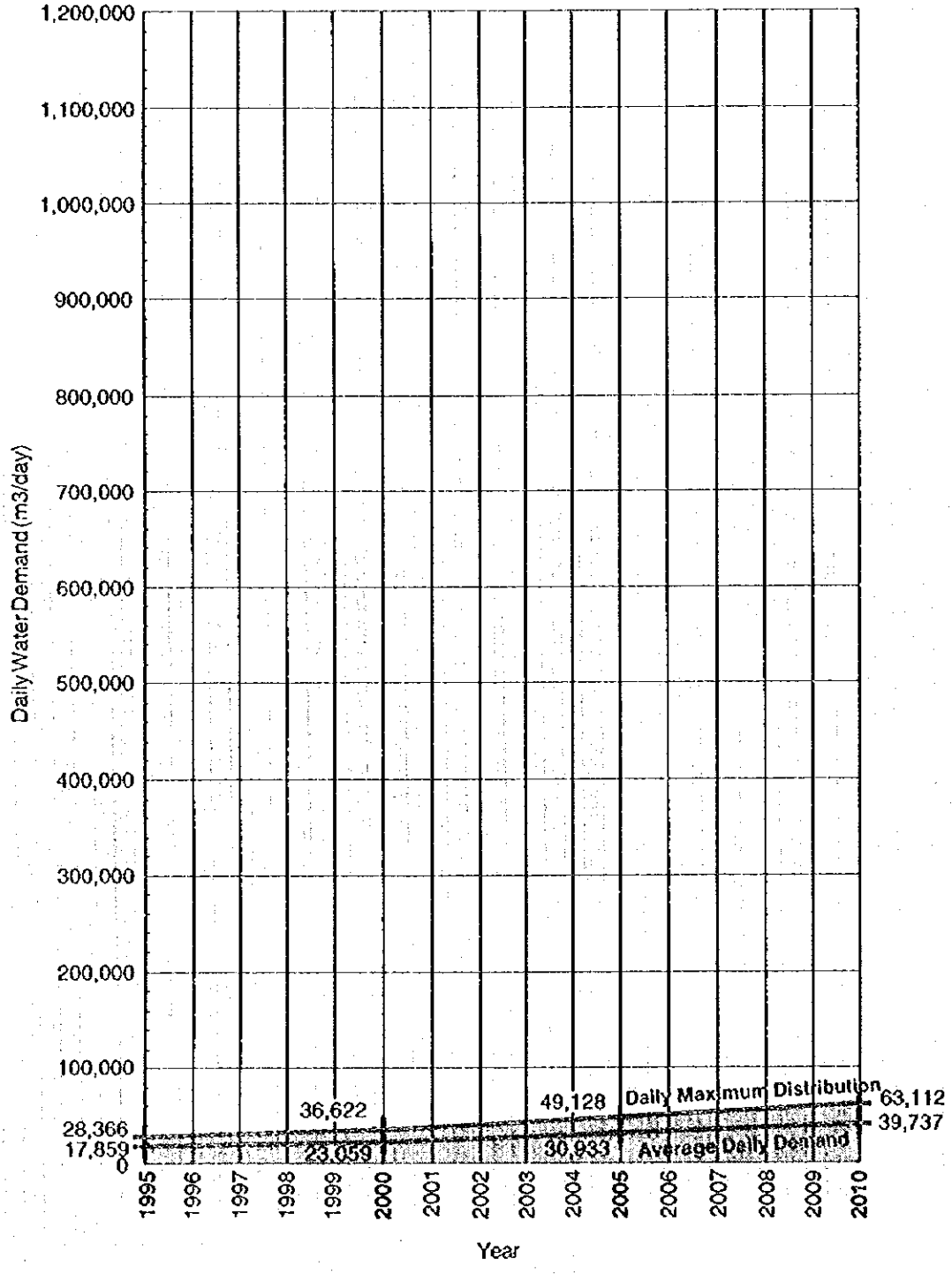


Fig. 1.5-6 Water Distribution Forecast
Rural Area
(Group R)

(4) Examination for the water demand forecast

The per capita water demand including all categories is shown in Table 1.5-10.

Table 1.5-10 Per Capita Water Demand Including All Categories (l/c/d)

Year	2000	2005	2010
Group U	238	271	303
Group D	232	279	316
Group R	60	75	90
Average	177	208	236

The per capita water demand of Group D is higher than Group U, because of high industrial water demand in Group D.

The per capita water demand in 2010 of Group U and D is respectively exceeds 300 l/c/d which is a reasonable figure for Hanoi as a capital in a country.

The water usage of the whole Hanoi is shown in Fig. 1.5-7.

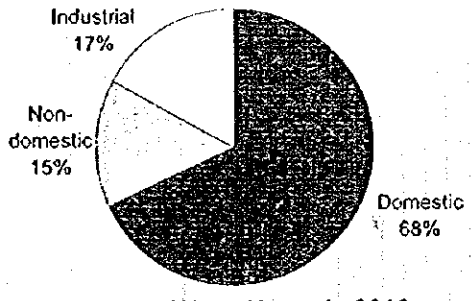


Fig. 1.5-7 Water Usage in 2010

In the case of Group D, the rate of domestic water demand among all usage in Group D accounts for 61%, that is lower than the case of the whole Hanoi. On the other had, the industrial water demand amounts to 29% whereas 17% of whole Hanoi. This is because many industrial estates are going to be rapidly developed in these areas.

The water demand of each group in 2010 is presented in Fig. 1.5-8.

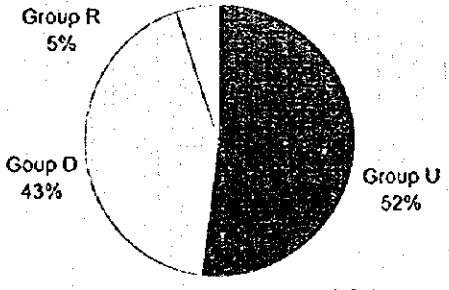


Fig. 1.5-8 Water Demand of Group

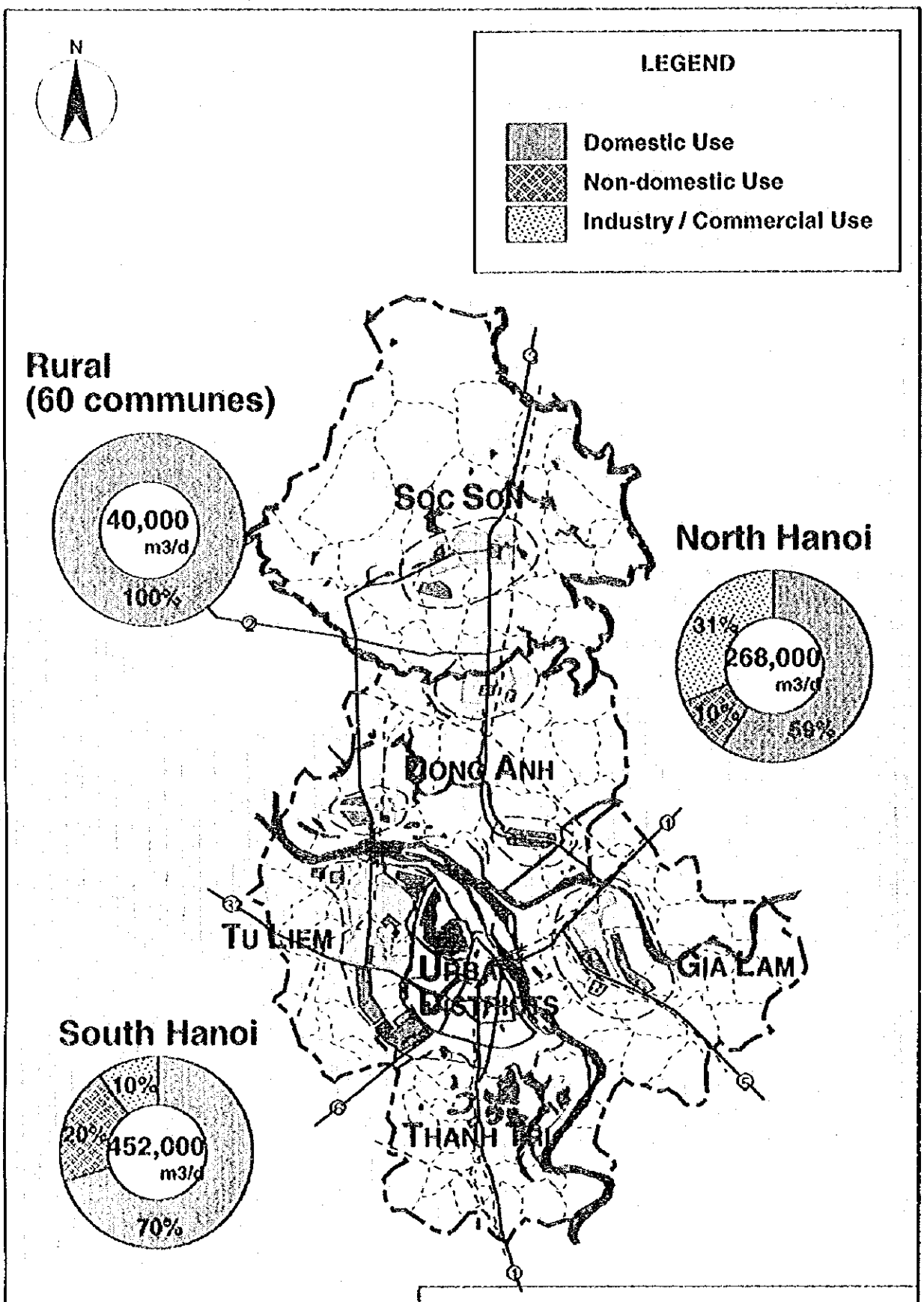


Fig. 1.5-9
Ratio among Water Usage by Area

1.6 WATER SOURCES

1.6.1 Priority Water Sources

Hanoi city has been taking groundwater as the water source for its public water supply. In recent years, however, the water demand has been rapidly increasing due to the commercial and industrial development of the city. Taking into account of this quick changeful situation, it is important to examine whether the groundwater is appropriate for and adaptable as water source till 2010. From the several view-points, it has been examined in below.

(1) Water quality

According to the existing data (see Supporting Report A, 2.4.2 Water Quality) on water quality of rivers, higher concentration of toxic chemicals such as arsenic, lead and phenol was detected in the Red River and the Da River sometimes. A peril of contamination by pesticide can not be denied with regard to the other small rivers in Hanoi City such as the Cau River and the Cong River. For this reasons, it seems that the river water may be difficult to utilize for water supply, compared to groundwater.

However, it is not so easy to approve these higher concentration by looking over the river basins, Because, it seems that at least Da River basin has not been heavily developed for industrial or mining industry, and the river seems to have a big volume of water flow enough to dilute wastewater discharged from the industry. These values were obtained from monthly sampling only for one year (in 1994) and one time sampling, therefore future further consecutive water quality monitoring of these rivers will be necessary for more reliable conclusion.

On the other hand, from the groundwater, iron, manganese and ammonia is detected. Iron, manganese and ammonia can be removed easily by the present water treatment technology with reasonable cost. High concentration values of lead, phenol and cadmium were detected by occasional water quality analysis, which slightly exceed the water quality criteria. However, the sampling wells where phenol and cadmium were detected are very limited, therefore these high values may not show contamination of raw groundwater. As for lead, its concentration

though slightly high values are distributed in wide area. Therefore, it seems to be more realistic to utilize groundwater for water supply.

(2) Facility

Construction cost of a treatment plant for groundwater is lower than that for surface water, because of high turbidity. Chemical cost (one component of the operation cost) for groundwater treatment is lower than that for surface water, because of treatment process without chemical sedimentation.

Distance of transmission pipeline (for either raw water or treated water) for surface water is obliged to be longer than that of groundwater, because intake site for surface water is remote from populated area where water is consumed. Therefore, higher cost for the pipeline construction is required, and higher transmission cost (pumps and power cost) is also required.

The structures for intake facilities to be constructed in the river require much higher cost compared to the groundwater intake.

Cost comparison is given in table below in terms of Construction cost, O&M cost and Water cost.

	Groundwater	Surface Water	
		Da River	Red River
Construction Cost	100	210	185
(Intake Facility)	(10)	(20)	(35)
(Treatment Facility)	(35)	(50)	(80)
(Transmission Facility)	(15)	(100)	(30)
(Distribution Facility)	(40)	(40)	(40)
O&M Cost	100	120	150
Water Cost (O&M + Capital)	100	150	160

(Notes)

1) Above figures indicate the costs of each comparing item where the costs for groundwater system are 100.
2) Breakdown of the construction cost are shown as figures in brackets.
3) Water Cost, which includes O&M and Capital costs, is regarded as the base cost of water tariff.

(3) Priority Source

In conclusion, the groundwater can be available to the source for the water supply system.

1.6.2 Development Potential of Groundwater

(1) Basic conditions

As described before, a computerized groundwater model in Hanoi area has been established, by which groundwater conditions in future is simulated for the assessment of groundwater resources. The simulation has been revised every year using new observation data. The analysis of the development potential of groundwater in this study also follows basically the results of the simulation study in the area south and west of the Red River. Basic conditions of the analysis are as follows: (See, Fig.1.6-1 "Schematic Mechanism of Groundwater Recharge")

a) "Water Master Plan of Hanoi City" by FINNIDA in 1993 ("Water Master Plan" hereafter)" has confirmed that the lower aquifer Qa is the main aquifer for the groundwater development and the discharge of 700,000 m^3/d can be exploited from the aquifer Qa in the area south and west of the Red River without serious environment impacts.

This figure of 700,000 m3/d seems to be reliable. Because, this is obtained through the computer analyses of the groundwater simulation model using the authorized program, the elaborate model and the sufficient observation data. Furthermore, this figure of 700,000 m^3/d has been approved by the State Council for Approve of Mineral Reserves.

b) The meaning of above conclusion is that the groundwater of 700,000 m^3/d, namely 700,000 x 365 = 256 x 10^6 m^3/year corresponding to the discharge is rechargeable in a year.

c) In the "Water Master Plan", the Qa aquifer is to be recharged from surface water bodies comprising 30-35 %, the vertical percolation 60-65 % and lateral inflow 2-3 %.

In this study, it is assumed that the vertical percolation is of 60 %, surface water bodies of 30 % and lateral inflow of 10 % for South Hanoi, and the vertical percolation of 100 % for the other areas.

d) The area of South Hanoi is 253.58 km^2 (= 253.58 x 10^6 m^2) consisting of Thanh Tri, Tu Liem and Urban districts.
The annual rainfall (R) in Hanoi city is 1,794 mm and the annual evaporation (E) is 938 mm. Namely, (R - E) = (1,794 - 938) mm = 856 mm = 0.86 m.
Therefore, the annual percolatable water is: 0.86 m x (253.58 x 10^6 m^2) = 218 x 10^6 m^3.
Similarly,

- Soc Son.....0.86 x (313.86 x 10^6 m^2) = 270 x 10^6 m^3
- Dong Anh.....0.86 x (184.16 x 10^6 m^2) = 158 x 10^6 m^3
- Gia Lam.....0.86 x (175.79 x 10^6 m^2) = 152 x 10^6 m^3

e) Estimated vertical percolation is: 256 x 10^6 x 0.6 = 154 x 10^6 m^3 (See b), c)).
The rate of the estimated vertical percolation to the annual percolatable water is: (154 x 10^6)/(218 x 10^6) = 0.71(= 71%). This rate of 71% will be applied to all other districts. Therefore,

- Soc Son.....270 x 10^6 m^3 x 0.71 x 0.5* = 95.8 x 10^6 m^3
- Dong Anh.....158 x 10^6 m^3 x 0.71 = 112 x 10^6 m^3
- Gia Lam.....152 x 10^6 m^3 x 0.71 = 108 x 10^6 m^3

Note(*): In Soc Son, the distribution area of the Qa aquifer is assumed to be 50 % of the total area of the district.

f) Average transmissivity of the Qa aquifer in S.H (Tsr) is 1.67 x 10^{-2} m^2/sec. The rates of the average transmissivities of the Qa aquifer in other areas to Tsr are obtained as below. The characteristics of the Qa aquifer in each area is expressed with the rate multiplied by its estimated vertical percolation.

- South Hanoi.....1.67 x 10^{-2} m^2/sec (Tsr)
- Soc Son.....4.35 x 10^{-3} m^2/sec (0.25Tsr)
- Dong Anh...7.00 x 10^{-3} m^2/sec (0.42Tsr)
- Gia Lam.....1.90 x 10^{-2} m^2/sec (1.14Tsr)

g) Rechargeable groundwater

e) x f) (rates to Tsr), therefore,

- Soc Son.....95.8 x 10^6 m^3 x 0.25 = 24.0 x 10^6 m^3 = 66,000 m^3/d
- Dong Anh.....112 x 10^6 m^3 x 0.42 = 47.0 x 10^6 m^3 = 129,000 m^3/d
- Gia Lam.....108 x 10^6 m^3 x 1.14 = 123 x 10^5 m^3 = 337,000 m^3/d
- South Hanoi.....15.4 x 10^6 m^3 x 1.00 + α = 256 x 10^5 m^3 =700,000 m^3/d

α : Recharge from surface water bodies and lateral inflow.

(2) Results

Results of the analysis are shown in Table1.6-1 through Table1.6-4.

Table1.6-1 Groundwater Budget

	Name of Area	Area (km^2)	Rechargeable Groundwater (m^3/d)	Present Water Use (m^3/d)	Groundwater Budget (m^3/d)
1	Soc Son	313.86	66,000	6,000	60,000
2	Dong Anh	184.16	129,000	13,000	116,000
3	Gia Lam	175.79	337,000	19,000	318,000
4	South Hanoi	253.58	700,000	500,000	200,000
	Total	923.79	1,232,000	538,000	694,000

Note: Groundwater Budget = Potential of the groundwater development in future
This figure will be restricted with the conditions of the space for the wellfields.

South Hanoi (S.H)

In South Hanoi, the rechargeable groundwater of 700,000 m^3/d, which was proposed in the "Water Master Plan" by FINNIDA in 1993 and has been approved by the State Council of Mineral Reserves, covers the water demand of 670,000 m^3/d in the year 2010.

North Hanoi (N.H)

In North Hanoi, the rechargeable groundwater of 532,000 m^3/d have been estimated through the study based on results of the simulation study in S.H and the existing data. Although the rechargeable groundwater of 532,000 m^3/d will meet the water demand of 402,000 m^3/d in the year as a whole, some districts such as Soc Son and Dong Anh will lack the groundwater resources before 2010.

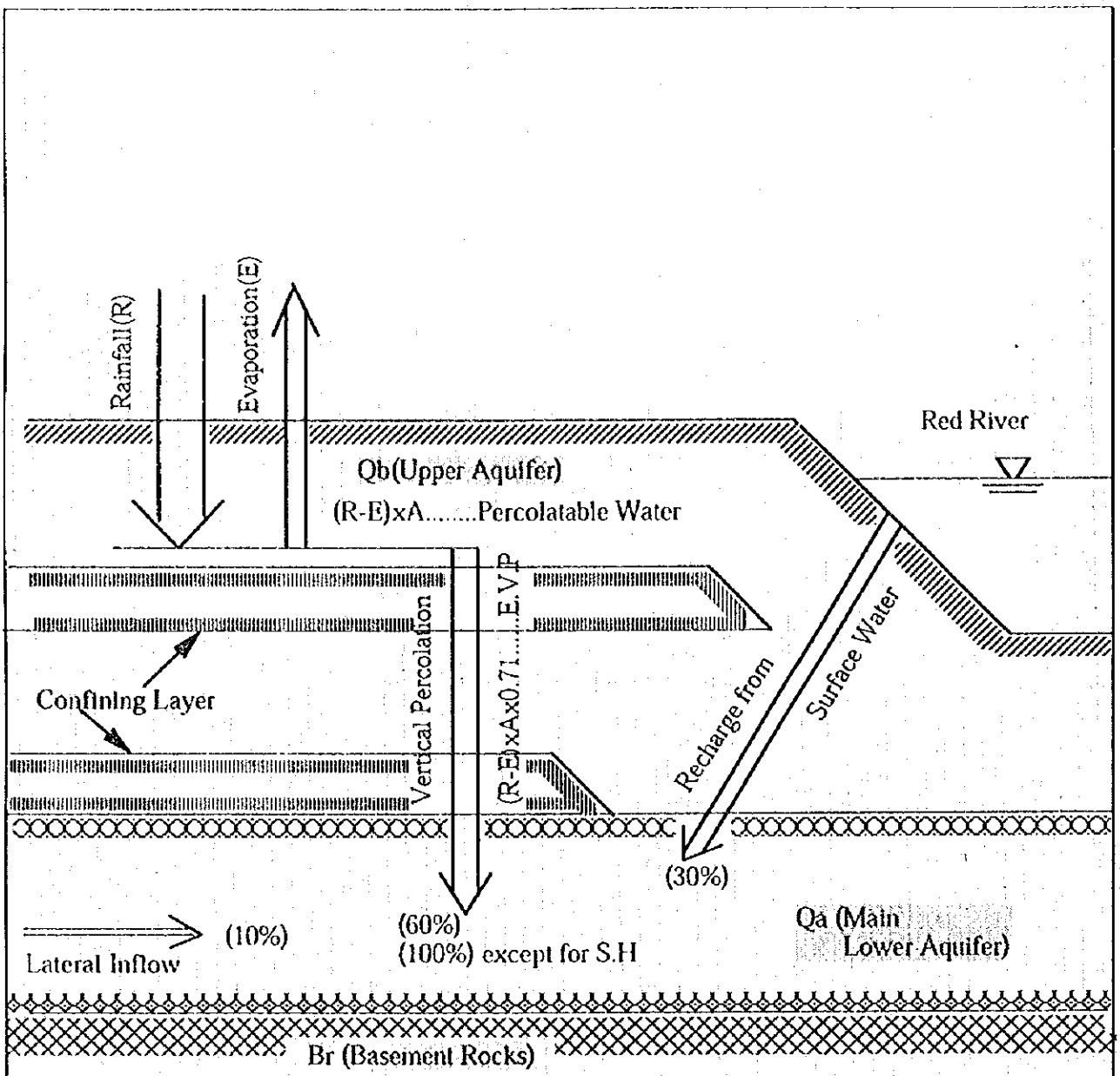


Fig.1.6-1
Schematic Mechanism of Groundwater Recharge

Table1.6-2 Balance of Groundwater Resources in 2000

(m^3/d)

Area	Budget	T. Demand	P.W.U.	I. Demand	Balance
Soc Son	60,000	36,000	6,000	30,000	30,000
(A)	-	24,000	6,000	18,000	-
(B)	-	12,000	0	12,000	-
Dong Anh	129,000	77,000	13,000	64,000	52,000
(A)	59,000	37,000	13,000	24,000	22,000
(B)	50,000	37,000	0	37,000	13,000
(C)	20,000	3,000	0	3,000	17,000
Gia Lam	337,000	93,000	19,000	74,000	244,000
South Hanoi	700,000	478,000	500,000	-22,000	222,000
Total	1,232,000	684,000	538,000	146,000	548,000

Table1.6-3 Balance of Groundwater Resources in 2005

(m^3/d)

Area	Budget	T. Demand	P.W.U.	I. Demand	Balance
Soc Son	60,000	61,000	6,000	55,000	5,000
(A)	-	45,000	6,000	39,000	-
(B)	-	16,000	0	16,000	-
Dong Anh	129,000	117,000	13,000	104,000	12,000
(A)	59,000	62,000	13,000	49,000	-3,000
(B)	50,000	51,000	0	51,000	-1,000
(C)	20,000	4,000	0	4,000	16,000
Gia Lam	337,000	130,000	19,000	111,000	207,000
South Hanoi	700,000	569,000	500,000	69,000	131,000
Total	1,232,000	877,000	538,000	339,000	355,000

Table1.6-4 Balance of Groundwater Resources in 2010

(m^3/d)

Area	Budget	T. Demand	P.W.U.	I. Demand	Balance
Soc Son	60,000	84,000	6,000	78,000	-18,000
(A)	-	62,000	6,000	56,000	-
(B)	-	22,000	0	22,000	-
Dong Anh	129,000	158,000	13,000	145,000	-29,000
(A)	59,000	85,000	13,000	72,000	-26,000
(B)	50,000	68,000	0	68,000	-18,000
(C)	20,000	5,000	0	5,000	15,000
Gia Lam	337,000	160,000	19,000	141,000	177,000
South Hanoi	700,000	670,000	500,000	170,000	30,000
Total	1,232,000	1,072,000	538,000	534,000	160,000

(Note)

Budget : Potential of groundwater development in future

T. Demand : Total Demand including estimated increasing private well intake (128,000 m^3/d)

P.W.U. : Present Water Use

I. Demand : Increased Demand = (T. Demand - P.W.U.)

Balance : (Budget - I. Demand)

To supplement the shortage of available groundwater both in Soc Son and Dong Anh districts, the following two plans are proposed:

Plan A: Groundwater from Gia Lam
Plan B: Intake from the Cau River

Fig.1.6-2 and Table1.6-5 show the system of the alternative plans and the summary of comparison between them, respectively.

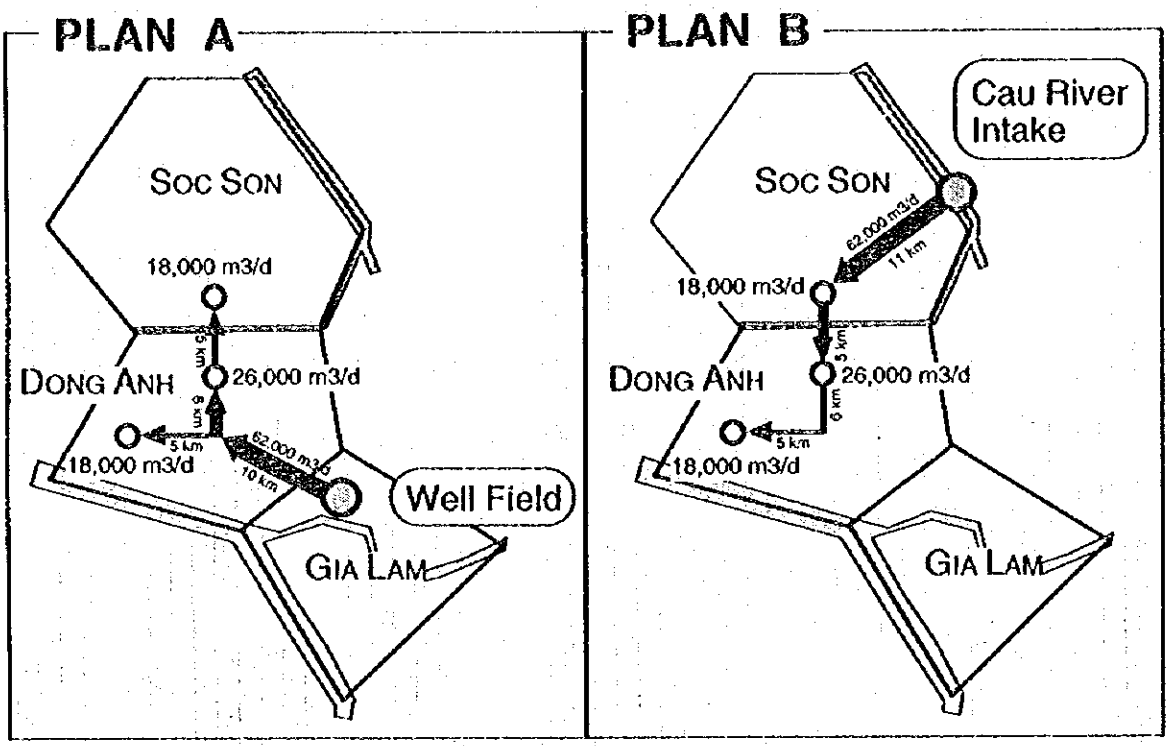


Fig. 1.6-2 The Alternative Plans

Table 1.6-5 Summary of the Comparison

	Plan A	Plan B
Water source	Groundwater (Gia Lam: North of Duong River) enough capacity for the discharge in 2010	Surface Water (Cau River) enough capacity for the discharge but detailed data is necessary.
Water discharge	more than 65,000 m^3/d	more than 65,000 m^3/d (Detailed data is necessary)
Water quality	Iron, manganese and ammonium Low seasonal fluctuation	Prone to be contaminated More subject to seasonal fluctuation
Proposed Treatment Process	Iron, manganese and ammonium removal system (Aeration + Filtration)	Turbidity and other organic matter removal system (Coagulation+Sedimentation +Filtration)
Construction Cost	The construction cost for the transmission main is lower than Plan B. ø900 mm x 10 km ø800 mm x 6 km ø500 mm x 10 km The construction cost for the treatment plant is lower than Plan B.	The construction cost for the transmission main is costly. ø900 mm x 11 km ø800 mm x 5 km ø500 mm x 11 km The construction cost for the treatment plant is costly, because of construction of the sedimentation basin.
Operation and Maintenance Cost	Approx. 800 - 950 VND/ m^3	Approx. 970 VND/ m^3 or more

From the above comparison, Plan A is concluded to be more practical. These districts can obtain water from Gia Lam district (See, Fig.1.6-3).

On the other hand, a feasibility study will be required in future on whether the surface water sources are applicable to the water supply system, because the groundwater will become insufficient from 2010 onward.

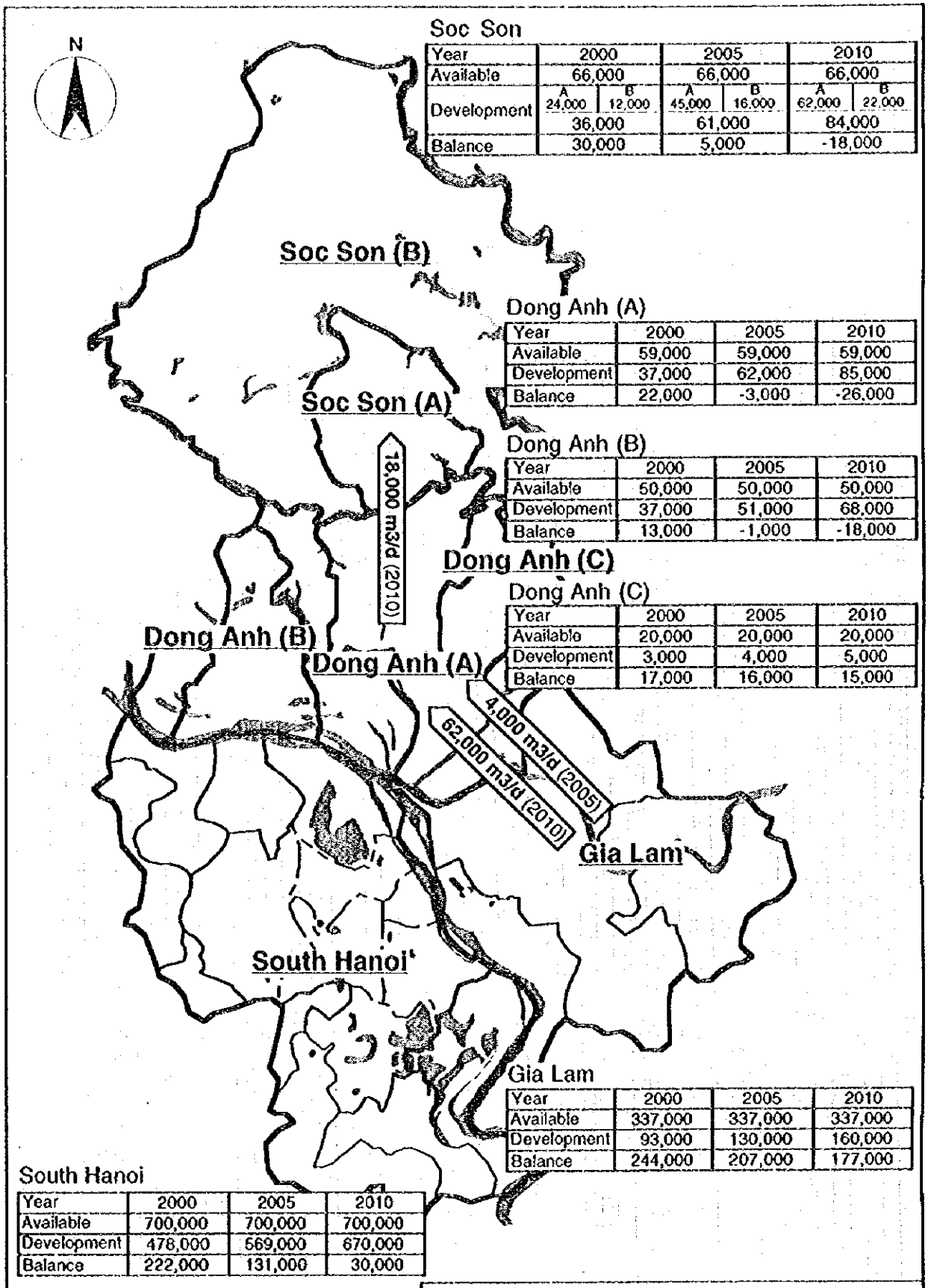
In the case of surface water use in future, the Cau River water for the both of two districts via Soc Son district could be considered. In this case, however, more detailed data for water balance analysis will be necessary.

As described in clause 2.2.3, (2), 2) Thai Binh River system, taking account of

some information about pump discharge, catchment area and rainfall, the minimum flow with 95 % probability of about 10 m^3/sec at the Cau River in Soc Son district would be reliable and the intake of less than 10 m^3/sec for water supply would be available enough. However, for the example, observation data of following items for several years will be required to be prepared by the Vietnamese Government.

- Rainfall data at the stations in the catchment area both of the Con River and the Cau River.
- Intake data for the irrigation canals at the Nui Coc dam and Thac Huong weir.
- Flow data of the Cau River in Soc Son district.
- Water quality data, particularly such as toxic matters.
- Other water intake rights data of the Con River and The Cau River in and around Soc Son district.

In order to suggest future water source, the case study on surface water intake has been made for reference, which is presented in the attached ANNEX "Case Study on Surface Water Intake".



Soc Son

Year	2000		2005		2010	
Available	66,000		66,000		66,000	
Development	A 24,000	B 12,000	A 45,000	B 16,000	A 62,000	B 22,000
	36,000		61,000		84,000	
Balance	30,000		5,000		-18,000	

Dong Anh (A)

Year	2000	2005	2010
Available	59,000	59,000	59,000
Development	37,000	62,000	85,000
Balance	22,000	-3,000	-26,000

Dong Anh (B)

Year	2000	2005	2010
Available	50,000	50,000	50,000
Development	37,000	51,000	68,000
Balance	13,000	-1,000	-18,000

Dong Anh (C)

Year	2000	2005	2010
Available	20,000	20,000	20,000
Development	3,000	4,000	5,000
Balance	17,000	16,000	15,000

Gia Lam

Year	2000	2005	2010
Available	337,000	337,000	337,000
Development	93,000	130,000	160,000
Balance	244,000	207,000	177,000

South Hanoi

Year	2000	2005	2010
Available	700,000	700,000	700,000
Development	478,000	569,000	670,000
Balance	222,000	131,000	30,000

Fig. 1.6-3
Groundwater Balance & Plan of Water Source

1.6.3 Water Quality of Groundwater

Probably higher concentration values are generally used for facilities design. The values for raw water quality were basically estimated referring concentration appearance probability. The values with non-excess probability of 75% were adopted for probably high values of raw water quality. In other words, three fourths of all values do not exceed this probably high value with non-excess probability of 75%. The results are summarized in Table 1.6-6.

Table 1.6-6 Probable High Concentration of Raw Groundwater

Parameter	Unit	South Hanoi		North Hanoi			Criteria for Drinking Water	
		North	South	Soc Son	Dong Anh	Gia Lam	Vietnamese (Urban Area)	WHO Guidelines
pH	-	6.7~8.3	6.8~7.0	6.1~6.8	6.1~6.6	6.6~6.8	6.5~8.5	-
NH_4^+	mg/l	1.8	17.8	0.4	1.9	3.1	3	1.5
NO_3^-	mg/l	1.3	0.4	1.7	2.6	1.0	10	50
Fe^{2+}	mg/l	2.6	10.9	-	-	-	-	-
Fe^{3+}	mg/l	0.2	0.4	-	-	-	-	-
Total Iron	mg/l	2.8	11.3	2.0	7.6	8.0	0.3	0.3
Hardness	mg/l	11	8	125	158	198	500	-
Mn	mg/l	1.0	0.3	0.1	0.2	0.3	0.1	0.5
TS	mg/l	153	-	122	166	303	-	-
SO_4^{2-}	mg/l	80	-	12	111	41	400	250
Phenols	mg/l	0.000	0.000	0.000	0.038	0.007	-	-
As	mg/l	0.00	0.00	0.00	0.00	0.00	0.05	0.01
Zn	mg/l	0.5	0.7	0.4	0.7	0.4	5	3
Cd	mg/l	0.008	0.006	0.005	0.020	0.008	0.005	0.003
Pb	mg/l	0.11	0.12	0.08	0.05	0.14	0.05	0.01
CN	mg/l	0.00	0.00	0.00	0.00	0.00	0.1	0.07
Hg	mg/l	0.000	0.000	0.000	0.000	0.000	0.001	0.001
Cu	mg/l	0.2	-	0.1	0.3	0.0	1	2
Cr	mg/l	0.01(VI)	-	0.00(VI)	0.02(VI)	0.01(VI)	0.05	0.05
F	mg/l	0.7	-	0.4	0.8	0.5	1.5	1.5

1.6 DESIGN CRITERIA

(1) Peak Day Factor

The peak day factor which will be applied to size dimensions of facilities of treatment plants, raw water intakes is to be 1.35 (135%). (1997-2010: Constant 1.35)

(Note 1)
Above factors are to be applied constantly through planning period till the year 2010.

(Note 2)
Supply to industrial estates is to be done on the basis of 24 hours constant supply as bulk water supply method, and peak factors are as follows:

- Peak day factor: 1.10 (110%) for industrial estates (1997 - 2010: Constant 1.10)
- Peak hour factor: 1.00 (100%) for industrial estates (1997 - 2000: Constant 1.00)

In the case that factories located in the industrial estates need storage facilities, the storage reservoirs shall be constructed by each factory in the factory yard and by the expense of the factory, in order to receive public water for 24 hours a day at a constant rate.

(2) Peak Hour Factor

The peak hour factor which will be applied to determine diameters of distribution pipelines is to be 1.40 (140%) of the peak day demand. (1997-2010: Constant 1.40).

(3) Volume of Distribution Reservoir

Volume of distribution reservoirs is to be 20% of the daily maximum (4.8 hours equivalent).

(Note)
Water storage for fire fighting:
In the case that the volume of the reservoir is less than 1,000 m3, a volume of 50 m3 or 100 m3 for fire fighting will be added to the reservoir volume.

(4) Water Pressure

The final target of supply pressure in distribution pipelines are to be:

- 30 meters in densely inhabited districts (DID) in order to supply four (4) storied dwellings or buildings and,
- 15 meters in rural areas.

(5) Raw Water Intake Capacity

Taking consideration of loss in the course of treatment, i.e. filter back-wash water and other miscellaneous use in the treatment plants, raw water intake capacity is set to be 105% of the production.