CHAPTER 2 IMPROVEMENT PLAN FOR WATER SUPPLY

2.1 Current Conditions of Water Supply

2.1.1 Current Water Demand

(1) Current Water Demand

Water consumption can be divided into domestic consumption, industrial consumption, commercial consumption and institutional consumption. Current water demand by category of use in the study area is presented below.

Current Water Demand by the Study Areas in 2000

	Class[1] A m^3/d	**Class B m^3/d**	**Class C m^3/d**	**Total m^3/d**
- Domestic water demand *	41,539	10,772	3,148	5,459
- Industrial water demand	5,838	528	200	6,566
- Commercial water demand	2,429	584	81	3,094
- Institutional water demand	5,623	1,552	38	7,213
- Total water consumption demand	55,429	13,436	3,467	72,332
- Non-revenue water	40,000	11,807	398	51,807
Average water demand	**95,429**	**25,243**	**3,865**	**124,139**

* Including all people in the study area

1) Domestic Consumption

According to the experience of WSCO, the domestic consumption through house connections varies between 90 lpcd and 120 lpcd when connection is metered.

2) Industrial Consumption

The present industrial water consumption is about 5,840 m^3/d in the urban center, about 140 m^3/d in Kien An, about 280 m^3/d in Quan Toan, about 200 m^3/d in the New Development area and about 100 m^3/d in Do Son. There is not centralized water supply in the planned new industrial zone in Minh Duc. On the north side of the planned new industrial zone, the present industrial consumption is about 1,200-1,500 m^3/d. In the Dinh Vu economical zone the present water consumption is about 10 m^3/d (June 2000).

3) Commercial Consumption

According to WSCO's billing records, the commercial water consumption in the urban center is about 7 % of the domestic water consumption. The

1 Class A area covers the three urban districts (Hong Bang, Le Chan, Ngo Quyen), and urbanized area around the 3 urban districts. Class B area covers Kien An, Do Son and Quan Toan. Class C area covers Minh Duc, Dinh Vu and New Development Area. See Section 2.3.3 for the classification of Class A-C areas.

corresponding figure is about 2 % in Kien An. In Do Son, the commercial consumption is nearly 80 % of domestic consumption due to the numerous hotels and restaurants in the area.

4) Institutional Consumption

Institutional water consumption includes hospitals, schools, offices etc. According to WSCO's billing, institutional water consumption in the urban center is about 15 % of the domestic consumption. In Kien An, institutional consumption is much higher, about 40 %, compared to the domestic consumption.

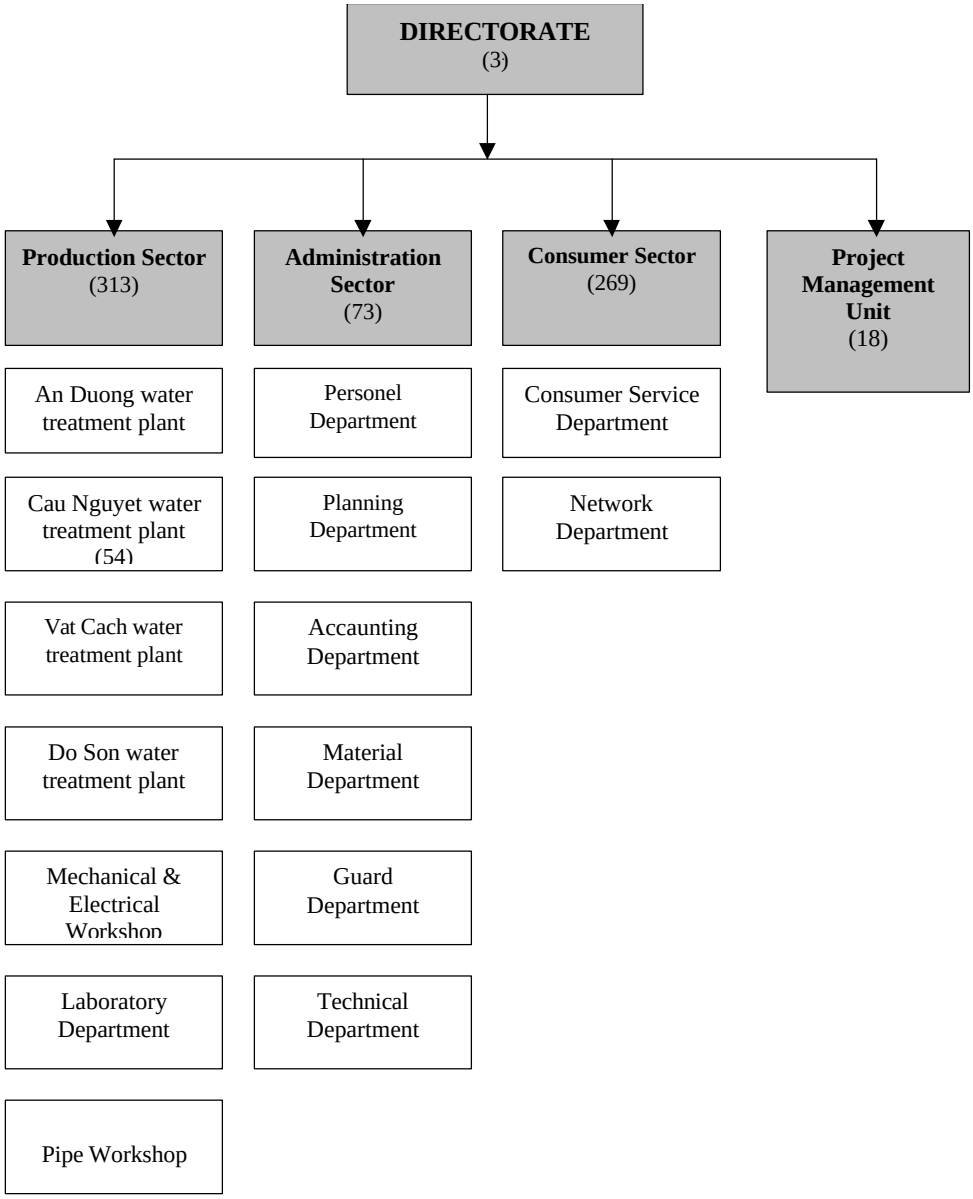
(2) Organizational Settings for Water Supply

1) Haiphong Water Supply Company, WSCO

(a) Organizational Structure

The company has strengthened its management mechanism and improved its institutional structure during recent years. The present organization of the company includes four sectors; Production, Consumer, Administration and Project Management. In the year 2000, the total staff of the company was 676, including Haiphong Water Supply and Sanitation Programme staff. There are a total of 9 departments directly under the Director of the company. The production sector is directly under the Deputy Director.

The organization chart of the company in 2000 is presented in the figure below:



Organization of Haiphong Water Supply Company in 2000

(b) The Mission and Strategy

According to the Corporate Strategy in 1998, the Mission of the WSCO is to "Produce and distribute high quality potable water to all its customers according to their demand at a reasonable price profitably".

The strategy and main objectives of WSCO for 2000 – 2005 have been defined in its Corporate Plan for 2000 as follows:

- produce at all times and as economically as possible clear drinking water to meet the needs of the whole city to WHO quality standards
- keep and conserve water resources

- expand the capacity of the waterworks so that supply is always ahead of demand
- ensure that the quality at the consumers' tap meets the quality standards of drinking water
- sell the water at the lowest cost possible, obtaining sufficient income, to cover all O&M and investment costs
- provide speedy, efficient and sympathetic communication between the public and WSCO service units
- maintain a proper morale among staff, to provide efficient, consistent and courteous services to the customers and to the public

One of HPWSo's main target is step by step increase water production to meet the water demand by the year 2010. The company will also continue the development toward self-financing agency with support from Finnish Government. Other mid term targets are:

- Company's institutional development, training to reach suitable management level meeting new demands
- Update the billing, collection and account receivable system
- Continue to update and develop Customers Network Development System (CNDS)
- Strengthening programs for reducing water loss and revenue loss
- Implementation of water sources protection program
- Continue to expand phuong model management

(c) Key Institutional Development Issues

WSCO is described being mentally prepared to become autonomous and self-sufficient. Creation of internal capacity, appointment of deputies, creation of a management team and strengthening of financial management are listed among the future priorities

The new topics for institutional development may include e.g.:

- Use of different financial instruments: tapping savings: own capital, banks
- Sharing of diminishing water resources, multiple water use
- Preparation for emergency situations, water source protection, water quality differentiation and risk / security management
- Strategic alliances and Joint Ventures in management of water production and distribution
- Privatization, outsourcing and other new alternatives to utility management
- Policies towards affordable water supply to all consumers and to the city

- Strategic service / market orientation for consumers; definitions of strategic know how, or water clusters vis-à-vis non-consumers; widening of area of services through strategic alliances
- Further improvement of billing and collection
- Water tariff policy in industrial promotion
- Social obligations of public enterprises

2) DVWSCO

The Dinh Vu Economic Zone Project (DVEZ) has been developed by the consortium of American Internal Group, Asian Infrastructure Development Company from Thailand and Internal Port Engineering and Management from Belgium. The three companies have developed the economic zone on a joint venture basis with a Vietnamese counterpart. For water supply service DVEZ has established Dinh Vu Water Supply Company, which is operating inside Dinh Vu Economic Zone area.

(3) Current Water Supply System

1) Area and Volume of Supply

The average water production of WSCO was about 108 587 m^3/d during 1999. The share of non-revenue water was 49.7 % of the total water production. From all water production, about 85 % of water consumption is currently metered. The share of non-revenue water varies in different distribution areas. In the improved areas of the urban center, non-revenue water represents about 20-25 % of the total water production, and in the worst areas, like Kien An and Vat Cach it can be as high as 70-80 %.

Due to the problem of raw water supply from the City, Dinh Vu water treatment plant has not been in operation up to end of June 2000.

Current water consumption in different distribution areas in 1999

Source: 2A Interim Report

Consumption category	Urban center m^3/d	Kien An m^3/d	Vat Cach m^3/d	Do Son m^3/d	Total m^3/d
Domestic consumption	33,790	2,410	720	760	37,680
Industrial consumption	5,840	140	710[1)]	140	6,830
Commercial consumption	2,240	60	310	600	3,210
Institutional and other consumption	5,530	1,070	150	520	7,270
Total consumption	47,400	3,680	1,890	2020	54,990
Non-revenue water	40,000	10,500	3,800	1,910	56,210
Average water production	87,400	14,180	5,690	3,930	111,200

1) Includes also Nomura industrial zone

The current water supply service area is shown in Figure 2.1.1.

2) Water Distribution

The existing water supply network is divided into four distribution areas as follows:

- Central area (Haiphong urban center: Hong Bang, Ngo Quyen and Le Chan districts, supplied by the An Duong treatment plant)
- Kien An (Kien An district, supplied by the Cau Nguyet treatment plant)
- Vat Cach area (western part of the city: Quan Toan and Hung Vuong phuongs, supplied by the Vat Cach treatment plant)
- Do Son area (south-eastern part of the city, supplied by the Song He intake and Do Son treatment plant)

In the urban center, the service area of WSCO covers, in principle, all phuongs. In the Kien An district, the service area comprises the center of Kien An. In Vat Cach, the service area covers some industrial plants and housing along the Haiphong - Hanoi road, and the housing quarters in the Quan Toan area. In the holiday resort of Do Son, the service area covers the tourist area.

The oldest part of the water supply system in Haiphong dates back to French colonial time i.e. during the first half of the twentieth century. The major part of the existing transmission and distribution pipelines was constructed at that time, and is still functioning as a part of the water supply system. Since 1990, when Haiphong Water Supply and Sanitation Programme was established, a great part of the old main pipes (nearly 20 km), and about half of the distribution system in the city center has been rehabilitated. The customer service level has improved continuously by installing new house connections with water meters. The pressure level in the rehabilitated network has also improved continuously.

(a) Urban Center

The central water distribution area is defined as the urban center of Haiphong (mainly including the urban districts of Hong Bang, Ngo Quyen and Le Chan). The service area comprised nearly 73,000 house connections, serving about 325,000 consumers (WSCO's estimate). The remaining inhabitants are served by public taps and tanks. During 1999, water loss in rehabilitated phuongs was 16.4 % whilst total loss in the urban center was 41.1 %.

The distribution network in the urban center is divided into high pressure and low pressure distribution zones. About 60 % (in 1999) of the urban center belongs to the so called high pressure network (Le Chan district and major part of the Ngo Quyen district). The total length of distribution

pipelines is 104.4 km. The distribution network in these areas has been improved by Haiphong Water Supply and Sanitation Programme (HPWSSP) during the 1990's. Nearly 100 % of the households have water meters and water supply is continuous in normal conditions in the rehabilitated areas.

At the end of 1999, the low-pressure network consisted of 13 unimproved phuongs (Hong Bang district and a part of the Ngo Qyuen district) which will be rehabilitated in 2000 – 2002 in the 1A Water Supply Project. Water loss is high in these phuongs, being generally about 70 %. Only about 40 % of the consumers have a contract with WSCO and about 60 % of distributed water is supplied through public tanks in the low pressure network.

In the urban center, there are four booster stations, which operate during peak demand to improve the service level. The booster pumping stations are located at Dinh Tien Hoang in the center, Nga Nam in the north-eastern part of the center and Dong Quoc Binh and Cau Rao in the southern part of the center. One new booster pumping station will be constructed in May To in the 1A Water Supply Project.

Figure 2.1.2 shows the current water supply network in the City Center.

(b) Kien An Distribution Area

The total length of main pipelines (250–600 mm) in the Kien An distribution area is about 27 km. Actual distribution network has not been constructed in Kien An. Houses or block of houses have direct connections to one of the mains running through the area. Major part of the network is old, and gray cast iron is the most common pipe material with mortar joints. The network is leaking heavily and water loss is about 70 %.

The total number of domestic house connections was about 8,500. In addition, there are two public tanks in Kien An, serving part of the population.

Figure 2.1.3 shows the water supply service area and the existing water supply network in Kien An.

(c) Vat Cach Distribution Area

The total length of main pipelines (300-600 mm) in the Vat Cach distribution area is about 13.6 km. Actual distribution network has not been built in the area. Therefore, most of the customers have direct connections to the water mains, which are located along the streets. In the Quan Toan area, the distribution system was improved in 1996, including new distribution pipes and new house connections with water meters. In Vat Cach, there were about 1,200 domestic house connections (mainly in Quan Toan and Hung

Vuong). The number of non-domestic connections is about 80. In addition, there is one public tank in Quan Toan.

Figure 2.1.4 shows the water supply service area and the existing water supply network in the Vat Cach-Quan Toan area.

(d) Do Son Distribution Area

The Do Son water distribution area covers the Do Son tourist area and the Song He area. Do Son water treatment plant receives pre-treated raw water from the Song He pumping station. This pre-treated water is also distributed directly to consumers along the Do Son road.

The total length of main pipelines (200-400 mm) is about 21.4 km. A distribution network has not been built in the area. Therefore the house connections are connected directly to the water mains.

In Do Son and along the main road from Haiphong, there are about 1,900 domestic house connections. During the tourist season such as summer time, water consumption about doubles compared to the normal consumption. Local hotels and restaurants form the major part of commercial customers.

Figure 2.1.5 shows the water supply service area and the existing water supply network in Do Son.

Length of mains and distribution pipelines in Haiphong
(Haiphong WSCO 1999)
Source: 2A Interim report & WSCO

Pipe diameter	Hong Bang	Le Chan	Ngo Quyen		Kien An	Vat Cach	Do Son
	Old	Improved	Improved	Old			
[mm]	[m]	[m]	[m]	[m]	[m]	[m]	[m]
150	8 750	12 716	9 059	3 350	1 000	500	2 000
200	6 100	6 373	9 155	1 500	1 500	1 000	5 070
250	2 500	2 968	1 012	1 500	8 500	-	3 072
300	5 200	3 014	2 833	500	-	8 800	-
400	3 800	6 620	6 150	3 200	8 093	2 400	11 300
500	-	-	1 100	-	-	-	-
600	2 040	3 250	1 700	-	8 000	880	-
Total	28 390	34 941	31 009	10 050	27 093	13 580	21 442
Grand total							166 505

3) Leakage and Unaccounted for Water

(a) Unaccounted-for Water

WSCO has monitored water losses since 1992 when the treatment plants were equipped with master meters. The definition of water loss in Haiphong was somewhat indefinite because water consumption also includes non-metered and non-billable terms. In addition, collection of earlier bad debts from customers were converted back into consumed water-m^3.

Authorized use from public tanks and taps, approved yearly by the People's Committee, were billed monthly without written bills according to estimated consumption 3 m^3/capita/month.

Non-Revenue Water (NRW) is a more accurate and internationally recognized indicator for water loss follow-up. UFW contains non-billed water uses which NRW does not. The difference in terminology can be seen in the following table.

Water loss as the follow-up by WSCO and NRW in Haiphong

	1993	1994	1995	1996	1997	1998	1999
Water loss (UFW) %		60	64	56	51	48	46,6
Non–Revenue Water %	71	69	68	64	57	54	49,7

The table above shows that the water lost and NRW has decreased rapidly during the past few years. This is an achievement of the phuong improvement program implemented by Haiphong Water Supply and Sanitation Programme. The NRW will be further reduced when the 1A project and other new water metering projects are launched.

NRW by areas	1997	1998	1999
Total service area	57 %	54%	49,7 %
City Center	49%	46%	41,1 %
Improved Phuongs	21%	19%	16,4 %
Old Network areas	60 – 80%	60 – 80%	60 – 80 %

Water loss in the improved phuongs varies among areas: in the early rehabilitated areas (1993-95) NRW in 1997 was over 30 % while in the later rehabilitated areas (1996-1999) it is now below 15 %. Some phuongs have NRW as low as 5 – 10 %. The reasons for this include improved designs, materials and construction practices.

There are plans to improve water distribution networks and meter all customers in the entire old network area by the year 2005.

(b) Leakage Detection

Information on repaired leaks in the mains has been collected since 1991. The information consists of leakage repair reports (completed for about 50 % of all the repaired leaks; consultant's estimate) and monthly summaries of leakage repairs. This information is not complete, but gives us a reasonable picture of the level of leakage repair activities.

The company has a telephone number for the public to inform about leaks. All the informed leaks are to be recorded. Judging by the number of incoming calls, it seems that people are not well aware of this service.

The most important source of leakage information is WSCO workers, although leaks informed by them are not recorded systematically.

Leakage information and repair in Distribution network 1996 – 1999

	Leaks informed by, Nos.			Leaks repaired, Nos.	
	Customers	Workers	Leaks detected	<65	>= 80
1996	2	33	6	17	24
1997	6	99	3	88	46
1998	5	95	9	326	103
1999	13	386	49	355	93

Number of leaks reported in Main network in 1999

Causes of leakage	Total
1: The main pipelines are too old	
Over D150	32
Under D150	3
2: The customers connections are too old	55
3: The surface is weak and pipeline is influenced by the traffic	
Over D150	5
Under D150	1
4: The pressure is too high	
Over D150	2
Under D150	0
Total	98

Reporting leaks has increased remarkably since the beginning of 1998 when a leak detection group was established and leak detection work was truly activated.

Advisers of HPWSSP have observed that it generally takes 4 - 7 days to repair a small to medium sized leak in the main streets. Only very big leaks are repaired the next day or night after. The lead time before preparation is often unnecessarily long. Authorization for leak repair and street excavation has to be obtained from TUPWS (Transportation and Public Works Service) and this often takes several days.

4) Intakes and Treatment Plants

There are four water intakes in the study area operated by WSCO: Quan Vinh, Vat Cach, Cau Nguyet and Song He. Water treatment plants are in Vat Cach, An Duong, Cau Nguyet and Do Son.

(a) Quan Vinh Intake and An Duong Treatment Plant.

The average production of the An Duong treatment plant was about 87,000 m^3/d in 1999. The unit operations include raw water storage and pre-sedimentation, raw water pumping, coagulation, sedimentation, filtration, backwash water recovery, chlorination, and treated water storage

and pumping. At present the raw water is pumped about 4.0 km from Quan Vinh to An Duong.

(b) Cau Nguyet Intake and Treatment Plant

The Cau Nguyet treatment plant operates at about 14 000 m^3/d, well below the design capacity. The reasons for this situation are the poor condition of the distribution network, high unaccounted-for water, and also, to some extent, poor power supply. On the other hand, the design capacity is far bigger than the water demand in the Kien An area, and no water is transmitted to the center due to the poor condition of the transmission lines. The unit operations comprise coagulation, pre-sedimentation, pumping, filtration, chlorination, and treated water storage and pumping. Cau Nguyet plant draws its raw water from the Da Do River.

(c) Vat Cach Intake and Treatment Plant

The design capacity of the Vat Cach treatment plant is 11,000 m^3/d, but at present, the average production is about 5,700 m^3/d. The share of unaccounted-for-water is high in the distribution system. The unit operations are raw water pumping, pH adjustment, coagulation, flocculation, sedimentation, filtration, chlorination, treated water storage, and treated water pumping.

(d) Song He Intake

The Song He intake serves the Do Son treatment plant and the Do Son road area. The treatment for the water supplied to the Do Son road area is minimal (alum dosing into the incoming flow at the intake). The raw water quality in any case makes it unsuitable for public water supply, and it is suggested that the intake should be closed.

(e) Do Son Treatment Plant

The Do Son treatment plant supplies water to Do Son town and the tourist hotels and guesthouses. The capacity of the plant was extended in 1991 from 1,000 m^3/d to 5,000 m^3/d, as a part of the Government's five-year plan.

(f) Dinh Vu Treatment Plant

Dinh Vu Water Supply Company will use the new Hoa Binh irrigation channel for raw water source. Haiphong City is supplying raw water to the Dinh Vu island by a new pumping station, located at the end of the new channel.

Key data on the water treatment plants are summarized in the hollowing below.

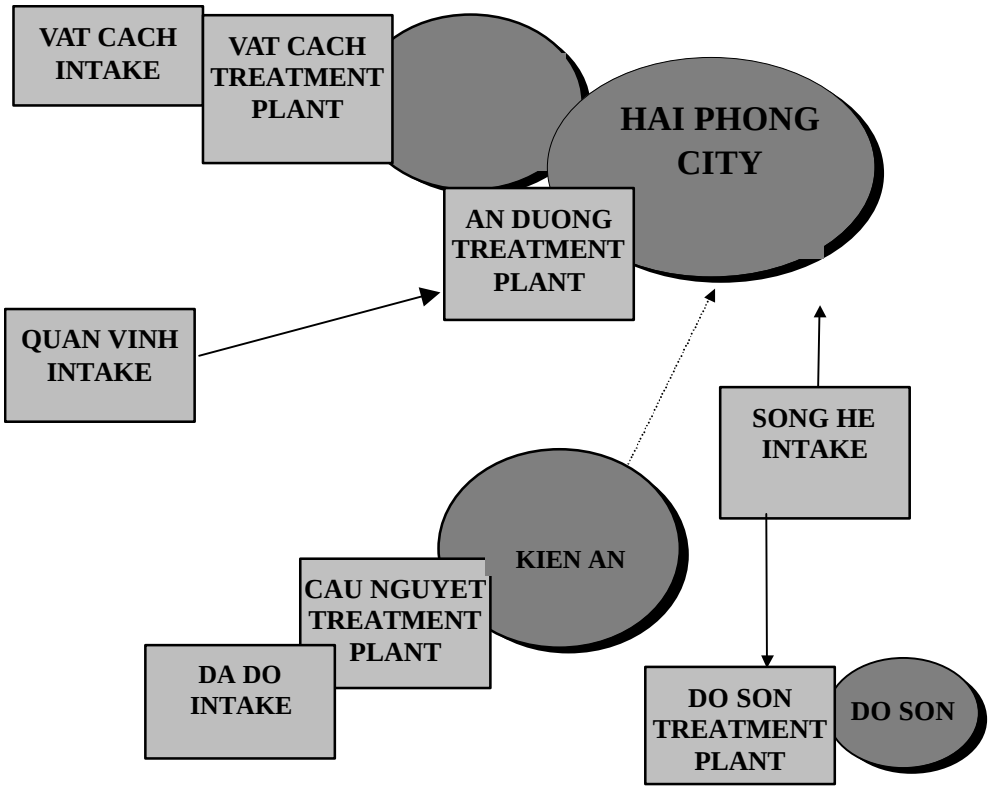
Present water treatment plants in Haiphong

Source: 2A Interim & WSCO

Treatment plant	Design capacity m^3/d	Average production m^3/d	Year of commissioning
An Duong	6,000 [1)]	87,400	1962, 1973
Cau Nguyet	60,000 [2)]	14,200	1977, 1979
Vat Cach	11,000	5,700	1988
Do Son	5,000	3,100	1964
Song He		800	
Total	136,000	111,200	

1) After rehabilitation / extension in the 1A Project, the capacity will be 100 000 m^3/d
2) Only the II phase is in working order, with a design capacity of 40 000 m^3/d

The intakes, booster pumps and treatment plants in Haiphong are shown in Figure 2.1.6. A simplified layout of the main water supply system in Haiphong is presented in the following figure.



Water treatment system

Source: Feasibility study 1995

5) Raw Water and Treated Water Quality

WSCO has carried out a water quality monitoring program that was planned by HPWSSP of raw water intakes and water treatment plants from November 1991. Samples of raw water and treated water are taken at every

water treatment plant every working day and every second week from possible new raw water sources. The monitoring program was revised according to the latest needs, in May 2000.

The water quality targets have been set in Corporate Plans of WSCO. The general target is that water quality at customer's taps meets the requirement of Vietnamese domestic water standard. The target of treated water turbidity is to fulfil the Vietnamese Standard (<1 NTU) during all seasons. To ensure the hygienic quality in water pumped from the treatment plants to the network, free chlorine must be 0.6 – 1.0 mg/l. Free chlorine in the improved network (in improved phuongs) should be at least 0.1 mg/l. The targets set for 2000 are shown in table below.

Water quality targets in 2000 according to Corporate Plan

Turbidity (NTU)	Target
An Duong	<0.8
Cau Nguyet, Vat Cach, Do Son	<0.5
Allowed daily max	1.0
Salinity (mg Cl / l)	
An Duong, Cau Nguyet, Vat Cach	<100
Do Son	<200
Free chlorine (mg/l)	
An Duong, Cau Nguyet, Vat Cach, Do Son	0.6-1.0
Coliform bacteria (pc/100 ml)	
An Duong, Cau Nguyet, Vat Cach, Do Son	0

The central water laboratory of WSCO is located in An Duong water treatment plant. The laboratory takes and analyzes all samples and reports the results to concurred organizations. Small laboratories have been established in summer 1993 for daily control of water quality in Vat Cach, Cau Nguyet and Do Son water treatment plants. All the laboratories are supported by HPWSSP and the central laboratory is one of the few water laboratories in Haiphong which can fulfil international requirements.

Water quality analyses and analyzing methods
used in the central laboratory of WSCO

Parameters Analysed Daily	Unit	No. in Standard Methods (17 ed.1989)	Method
Temperature	°C		Thermometer
Turbidity	NTU	2130	Nephelometric, Hach X/R
PH		4500 H^+	Electrometric, Hach One
Conductivity	µS/cm	2510	pH-meter
Chloride	mg/l	4500 Cl^- B	Hanna 8820 Conductivity Meter
Alkalinity	mg/l	2320	Argentometric Method
Total hardness	°dH	2340 C	Titrimetric method
$KMnO_4$-value	mg O_2 /l		EDTA Titrimetric Method
Free chlorine	mg/l		Acidic 10 min Boiling Method
Total coliform	pc/100 ml	9222 B	Colorimetric, Hach Comparator
Faecal coliform	pc/100 ml	9222 D	Membrane Filter Procedure
			Membrane Filter Procedure
Parameters Analysed Monthly			
Ammonia	mg/l		Colorimetric, Hach Comparator
Nitrite	mg/l		Colorimetric, Hach Comparator
Nitrate	mg/l		Colorimetric, Hach Comparator
Phosphate	mg/l		Colorimetric, Hach Comparator
Suspended Solids	mg/l		Gravimetric, Glass-Fibre Filters
Total iron	mg/l	2540 D	Colorimetric, Hach Comparator

(a) Turbidity

Turbidity is considered one of the most important indicators of drinking water quality. According to yearly averages the raw water turbidity has decreased in An Kim Hai channel (Re river), which is the raw water source for An Duong and Vat Cach treatment plants. Raw water turbidity is highest during the rainy season, usually in June - September, but there can be large variations in turbidity level between years, depending on the amount and timing of rainfall. Treated water turbidity has decreased remarkably in every water treatment plant due to improvements in treatment processes such as especially improvement in management of operation methods chemical dosing and backwashing of filters. For the time being, all water treatment plants are able to reach the targets given in Corporate Plans of WSCO even during the rainy season. Treated water turbidity is stable all the year round and in practice there are no more high peaks during summer.

Treated water turbidity (NTU) and reduction (%) in water treatment plants, yearly averages in 1992 – 1999

	An Duong		Vat Cach		Cau Nguyet		Do Son	
	NTU	Red %	NTU	Red %	NTU	Red %	NTU	Red %
1992	4.1	78.7	2.5	90.9	4.7	85.8	6.6	52.3
1993	2.7	79.8	1.9	89.7	4.0	86.5	2.6	63.1
1994	2.6	83.2	1.5	90.9	1.9	93.6	1.9	77.0
1995	1.1	86.2	0.9	93.4	1.2	95.5	1.8	87.0
1996	0.8	89.3	0.7	94.4	0.9	96.4	0.7	91.9
1997	0.6	90.3	0.6	93.8	0.7	96.5	0.7	91.9
1998	0.6	90.2	0.4	98.1	0.5	97.9	0.6	92.4
1999	0.6	90.7	0.4	96.7	0.4	98.3	0.5	90.0

Source: WSCO

(b) Salinity, Conductivity and Hardness

Salinity could be a problem during the dry season at the Quan Vinh intake, which serves as raw water source for the An Duong water treatment plant. Saline intrusions through Cai Tat gate were possible before the gate was repaired. According to Provisional Environmental Criteria, in the coastal area the limit of chlorides is 250 mg/l, which is seldom exceeded at Quan Vinh. Salinity is not a problem at Vat Cach or Cau Nguyet. In Song He and Do Son salinity is a continuous problem not only in the dry season but throughout the year. Even the averages from 1995 onwards are often close to or exceed the allowable limit, and the maximums can be very high. The maximums have exceeded 1000 mg/l several times. The situation was especially difficult in 1998 and even the annual average over 250 mg/l. The cause of salinity is the operation of tidal gates. Co-operation between WSCO and the Irrigation Service in the Department of Agriculture and Rural Development has already started to minimize this problem.

Raw water salinity (mg Cl/l) in Song He, monthly averages in 1992 – 1999

	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Avg
1992	124	104	114	100	91	133	91	154	126	57	45	42	98
1993	102	128	165	102	93	169	381	245	133	373	201	187	190
1994	119	156	127	132	158	196	170	449	47	46	70	79	149
1995	73	64	91	167	136		297	74	112	225	230	245	156
1996	162	184	198	129	137	111	164	236	72	253	202	135	165
1997	188	88	126	117	122	248	147	183	80	178	232	242	163
1998	176	197	246	249	178	191	147	129	131	454	608	422	261
1999	286	279	217	183	117	156	82	191	132	247	212	176	190

In 2A Water Supply Project, a new raw water intake and a treatment plant will be constructed next to Hoa Binh channel to replace the Song He intake and Do Son will then be used only as pumping station. Dinh Vu Economic Zone has it's own raw water intake from Hoa Binh channel and the Dinh Vu Water Supply Company Ltd has it's own water treatment facilities.

The water source to Hoa Binh channel is the Da Do River, which has very low salinity throughout the year. The monthly averages have varied in recent years from about 10 to 40 mg Cl/l. The water quality of the Hoa Binh channel shall be monitored frequently to identify the changes and the possible risks for raw water quality and to find out the need for mitigation measures. WSCO started regular monitoring in May 2000.

High chloride concentrations give a salty taste to water, but even more serious is that corrosion increases when the chloride concentration exceeds 50 mg/l. It is not economically possible to reduce chlorides in conventional water treatment process, and the only way to have low salinity is by selection of the raw water source.

Raw waters in Haiphong area can be classified as middle hard (total hardness is between 6 - 13 °dH -German hardness standard-) because concentrations of calcium and magnesium are high. The buffer capacity of the waters is good, but due to the reasonable high hardness, the boiler scale, which can increase corrosion, is a common problem.

(c) Hygienic Quality

Total coliform (TC) and faecal coliform (FC) bacteria are used as indicator bacteria. The amount of bacteria in raw water in every intake is quite high. The amount of bacteria is highest during the rainy season when leaching is strongest. There is no trend between the years and the changes are random.

Although the bacteriological quality of raw water is not very good, the bacteriological quality of treated water is for the time being very good due to the improved water treatment process and especially due to continuous chlorination. All water treatment plants fulfil the target that there is no indicator bacteria in treated water. The table below presents the improvement in bacteriological quality of treated water at the treatment plants as a percentage of good samples, meaning samples without indicator bacteria.

Percentage of treated water samples without total coliform bacteria in 1992 – 1999 at water treatment plants

	An Duong %	Vat Cach %	Cau Nguyet %	Do Son %
1992	82	20	15	63
1993	87	43	0	78
1994	93	83	29	87
1995	98	99	97	97
1996	100	100	100	99
1997	100	100	100	100
1998	100	100	100	100
1999	100	100	100	100

Source: WSCO

(d) Water Quality in Network

The analyzed parameters are the same as at the treatment plants. The positive impact of the improvement of the transmission mains and phuong network can be noticed from the data. The area of good water quality has widened all the time starting from An Duong. At present, treated water quality analyzed from taps in the improved phuongs is good. The amount of indicator bacteria is usually nil and free chlorine can be found even in the furthermost sampling points. Turbidity in network sampling points is a little bit higher than at the treatment plant. Continuous pumping is essential to keep the water quality in network at a good and stable level.

2.2 Current Problems for Water Supply

2.2.1 Water Treatment

The capacity of water treatment plants covers the present demand of water consumption. However, the main water treatment plant, An Duong, is currently operated at 20–30 % over its nominal capacity, and the impurities in its raw water tend not to be easily removed as those in the raw water of other treatment plants. During the dry season there are occasionally problems with raw water salinity because the irrigation department discharges water from the Lach Tray River to the Re River for irrigation purposes. The capacity problem of An Duong treatment plant will be solved during implementation of the 1A Water Supply Project.

In Vat Cach and Cau Nguyet there are minor technical problems, which will be solved partly by 2A Water Supply Project and partly by WSCO's regular improvement projects.

In Do Son the biggest problem is the high salinity of raw water taken from Song He intake, which is located about 10 km from Do Son water treatment plant. The New Hoa Binh intake and water treatment plant will be constructed in 2A Water Supply Project to replace Song He intake.

2.2.2 Water Distribution

One of the biggest problems in the whole distribution system has been the high non-revenue water percentage during last years. NRW was 49.7 % in the whole urban area but averaged about 17 % in the recently improved areas in 1999. The main reasons for high NRW have been non-metered customers and leakage in the old network. Also service time has been limited in the city center area in so called low pressure network area, in Vat Cach area and in Kien An area.

Based on the development in recently rehabilitated zones (phuong model) it can be estimated that the NRW percentage of in the whole urban area will be reduced to 20-25 % when 1A and 2A Water Supply Projects have been implemented by the year 2006.

2.3 Estimated Water Demand

2.3.1 Specific Consumptions

Total water consumption consists of i) domestic consumption, ii) industrial consumption, iii) commercial consumption, iv) institutional consumption, and v) non-revenue water. In order to estimate the water demand, these five categories of water consumption were estimated separately.

(1) Domestic Consumption

The table below summarizes the anticipated unit domestic water consumption in the Effective Study Area.

Anticipated Unit Domestic Water Consumption

(unit: lpcd)

Class[2]	District/Area	1999	2000	2005	2010	2015	2020
Class A	Hong Bang, Ngo Quyen, Le Chan	91-108	100-112	120	130	130	130
Class B	Kien An, Do Son, Quan Toan	61-94	80-103	100-120	110-130	120-130	130
Class C	Minh Duc, Dinh Vu, New Development Area	91-123	103-120	120	120-130	120-130	130

Domestic consumption is the average unit consumption per capita multiplied by population served by house connection. In 1995, WSCO forecasted that the nominal water consumption would be 150 lpcd by 2000 based on the long-term monthly statistics of water consumption data.

However, in the near future all connections will be metered and at the same time water tariff will be increased which will encourage customers to save water. Based on above, WSCO decided in 1996 to decrease the earlier-determined nominal consumption of 150 lpcd to 130 lpcd starting from 2010 when all the connections are metered. These figures are the basis for water demand calculations of annual Corporate Plans of WSCO. Domestic water use (through house connections) in 1999 averaged about 100 lpcd in the urban center[3], 94 lpcd in Kien An and about 90 lpcd in Vat Cach.

The World Bank has accepted the use of the above figures in all World Bank financed water supply projects in Haiphong, i.e., 1A and 2A Projects, which were designed to meet the water demand in 2020. The JICA Study Team adopted the figure of 130 lpcd for domestic water consumption in 2020.

[2] See Section 2.3.3 for the classification of Class A-C areas..

[3] For referring the nominal consumption in other cities in Vietnam and neighboring countries, Asian Development Bank has published figures of nominal consumption in 1997 as following: Haiphong 121 lpcd, Hanoi 45 lpcd (presumably 145 lpcd), Ho Chi Minh City 136 lpcd and average in Asian countries 154 lpcd.

After reviewing the long-term water use statistics of WSCO, and a series of meetings with experts from 1A and 2A Projects, the same estimates were adopted in this Study as the most reliable estimates of water demand to 2020.

Population figures in this Study by the JICA Study Team were based on the population census of the department of Statistics. The same estimates were used for other sectors of the Study, namely, drainage, sewerage and solid waste management.

(2) Industrial Consumption

Industrial consumption is based on the present consumption according to the contracts and billing of WSCO. The present industrial water consumption is about 5,840 m^3/d in the city center (3 urban districts, i.e., Hong Bang, Le Chan and Ngo Quyen), about 140 m^3/d in Kien An, about 710 m^3/d in Vat Cach/Quan Toan (including also the Nomura industrial zone) and about 140 m^3/d in Do Son and along the Do Son road according to the contracts and billing of WSCO (1999).

For the water demand forecasts it is estimated that the industrial water consumption will be about 6,000 m^3/d in the city center. No growth is expected because the tendency is to move all bigger industry from the urban center to industrial zones. In Kien An, the industrial consumption is currently about 6 % of the domestic consumption, and the same proportion is estimated also in the future forecasts.

According to the forecast by WSCO based on long-term water consumption records, the industrial water consumption in Vat Cach/Quan Toan area is expected to grow to about 2,000 m^3/d by 2020. In addition, the water consumption of the Nomura industrial zone is estimated to rise to 6,000 m^3/d by 2020. In 1998 the Nomura company requested from WSCO 15,000 m^3/d as the maximum daily demand by 1998 (average demand about 13,500 m^3/d). However in 1998 the water consumption of the Nomura industrial zone was only about 530 m^3/d, and in 1999 it reduced to about 200 m^3/d. Therefore, in this study a lower water demand estimate is used.

In Do Son and along the Do Son road in the New Development area, there is also potential for industrial growth. The industrial water consumption is estimated to grow to about 360 m^3/d by 2020 in these areas.

The same industrial consumption figures have been used in the World Bank financed water supply projects in Haiphong.

(3) Commercial Consumption

According to WSCO's billing, the commercial water consumption in the urban center is about 7 % of the domestic water consumption, and about 2 % in Kien An.

The same proportion is assumed for the future forecasts. In Vat Cach/Quan Toan and Do Son, the proportion of water used for commercial consumption is larger. In Do Son, the commercial consumption has been nearly 80 % of domestic consumption due to the numerous hotels and restaurants in the area. The industrial growth is anticipated to attract also other services, therefore the commercial water consumption is estimated to grow from the present 310 m^3/d to 800 m^3/d by 2020 in Vat Cach/Quan Toan and from 600 m^3/d to 860 m^3/d in Do Son.

(4) Institutional Consumption

Institutional water consumption includes hospitals, schools etc. According to WSCO's billing, institutional water consumption in the urban center is about 15 % of the domestic consumption. This share is assumed to remain about the same also in the future. In Kien An, the share of institutional consumption is much higher (about 40 %) compared to the domestic consumption. This is due to the high number of schools, universities and hospitals in Kien An, compared to the quite limited coverage of domestic water supply. In the future, the institutional water consumption is estimated to grow about 3 % year in Kien An based on long-term service records.

(5) Non-revenue Water

Non-revenue water is the part of the water, which is produced but not sold (=billed). Non-revenue water comprises administrative losses (faulty records, wrong estimates of non-metered customers, illegal water use), physical losses (leakage in the network, connections and reservoirs, faulty metering) and system losses (operational use like flushing and cleaning and authorized use like non-billable water use from public tanks, fire fighting etc.).

Non-revenue water used in Haiphong was 46.6 % of the total water production during 1999. The share of non-revenue water varies in different distribution areas. In the improved areas in the urban center, non-revenue water represents about 10-28 % of the total water production. In 1999, the average non-revenue water was 16.4 % in the improved areas. All water production and about 81 % of water consumption are currently metered, so the figures can be considered quite reliable.

The share of non-revenue water is projected to decrease along with the rehabilitation of the transmission lines and the distribution network, and with metering of house connections. When the transmission and distribution system is improved in all distribution areas, the share of non-revenue water is estimated to reduce to 20 % of the total water production by 2020.

Table of water loss target

Unaccounted for water	2000	2005	2010	2015	2020
Total NRW %	46	34	26	25	20

2.3.2 Peak Factors

The total average water demand is calculated according to the total average water consumption and non-revenue water. Consumption variations are taken into account using peak day and peak hour factors.

The Vietnamese sector standards recommend that the peak day coefficient K_d, i.e., ratio of peak daily demand to average daily demand, is 1.2 - 1.4, and the peak hour coefficient K_h, i.e., ratio of peak hourly demand to average demand of peak day, is 1.5-1.6 for a community like Haiphong. The following figures are used in this study.

- K_d = 1.35 for domestic use and 1.1 for other use
- K_h = 1.5

The same figures were recommended in the Water Supply Development Plan (WSDP 1992), and they correspond quite well to the current water production variation at the An Duong treatment plan. According to WSCO, the maximum daily quantity pumped to the improvement network was, on average, about 1.2 times of that pumped in 1999. The An Duong telemetry system gives some information about hourly consumption variations. The peak hour pumping rate is currently about 1.25 – 1.5 times the average hourly pumping rate.

When calculating the peak daily consumption, the average water consumption is multiplied by peak daily coefficient of 1.35 for domestic use and 1.1 for other use.

2.3.3 Consumption by Area

(1) Class A; Urbanized Area

At the end of 1999, it was estimated that Haiphong Water Supply Company supplied water to about 370,550 people through house connections. About 325,000 of these in the urban center, representing about 88 % of the population served through house connections. The service coverage (through house connections) is about 68 % in the urban center. This will increase to over 90 % by 2002 when the 1A Water Supply Project is implemented. The following forecast assumes that the service coverage will grow to about 100 % by 2020 in the urban phuongs. In addition, the service area will be extended to cover the ring road area (Dong Hai, Dang Hai, Nam Hai (50 %) and Dang Lam rural communes next to the

Ngo Quyen district and Du Hang Kenh and Vinh Niem rural communes next to the Le Chan district).

A projection of estimated water demand in Class A, Urbanized area is presented below. It has been assumed that all customers will be served through house connections.

Projected water demand in Hong Bang district

		1 999	2 000	2 005	2 010	2 015	2 020
- Population		97 565	98 541	103 715	108 796	113 844	118 861
- Population served with h.c.		23 066	44 420	97 492	107 708	113 844	118 861
- Service coverage (house conn.)	%	24	45	94	99	100	100
- Number of domestic connections		5 705	11 105	24 373	26 927	28 461	29 715
- Unit consumption	Lpcd	108	110	120	130	130	130
- Domestic consumption, h.c.	m^3/d	2 491	4 886	11 699	14 002	14 800	15 452
- Domestic, public tanks	m^3/d	413	600				
- Total domestic consumption	m^3/d	2 904	5 486	11 699	14 002	14 800	15 452
- Industrial consumption	m^3/d	2 051	2 300	2 300	2 300	2 300	2 300
- Nomura	m^3/d	214	238	1 000	3 000	5 000	6 000
- Commercial consumption	m^3/d	861	880	1 265	1 508	1 703	1 828
- Institutional consumption	m^3/d	1 759	1 314	2 029	2 502	2 705	2 858
- Other	m^3/d	330	500	500	500	500	500
- Total non-domestic	m^3/d	5 215	5 232	7 094	9 810	12 208	13 486
- Total water consumption	m^3/d	8 119	10 718	18 793	23 812	27 008	28 938
- Non-revenue water	%	53	46	29	24	22	21
- Non-revenue water	m^3/d	9 000	9 000	7 500	7 500	7 500	7 500
Average water demand	m^3/d	17 119	19 718	26 293	31 312	34 508	36 438
Max day demand	m^3/d	18 657	22 162	31 097	37 194	40 908	43 195

Table Projected Water Demand in the Augmented Area 1

South of Hong Bang

		1 999	2 000	2 005	2 010	2 015	2 020
NAM SON							
- Population		6 288	6 351	7 417	8 546	9 674	10 803
- Service coverage (house conn.)		0	0	0	15	20	25
- Population served with h.c.		0	0	0	1 282	1 935	2 701
- Unit consumption	Lpcd	91	103	120	130	130	130
- Domestic consumption	m^3/d	0	0	0	167	252	351
AN DONG							
- Population		14 608	14 754	17 440	20 076	22 371	24 654
- Service coverage (house conn.)		15	15	50	80	90	95
- Population served with h.c.		2 191	2 213	8 720	16 061	20 134	23 421
- Unit consumption	Lpcd	91	103	120	130	130	130
- Domestic consumption	m^3/d	199	228	1 046	2 088	2 617	3 045
- Total population served with h.c.		2 191	2 213	8 720	17 343	22 069	26 122
- Total domestic consumption	m^3/d	199	228	1 046	2 255	2 869	3 396
- Total number of connections		0	0	1 744	3 469	4 414	5 224
- Industrial consumption	m^3/d	0	0	0	0	0	0
- Commercial consumption	m^3/d	10	11	52	113	143	170
- Institutional consumption	m^3/d	10	11	52	113	143	170
- Total non-domestic	m^3/d	20	23	105	225	287	340
- Total water consumption	m^3/d	219	251	1 151	2 480	3 156	3 735
- Non-revenue water	%	53	46	28	23	21	20
- Non-revenue water	m^3/d	247	214	448	741	839	934
Average water demand	m^3/d	467	464	1 599	3 221	3 995	4 669
Maximum day demand	m^3/d	563	568	2 020	4 107	5 111	5 985

Note: h.c. means house connection

Projected water demand in Ngo Quyen district

		1 999	2 000	2 005	2 010	2 015	2 020
- Population in Ngo Quyen		171 623	173 339	177 017	181 890	186 765	191 642
- Population served with h.c.		131 688	135 334	141 614	169 158	183 030	189 726
- Service coverage (house conn.)	%	77	78	80	93	98	99
- Number of connections		28 123	31 473	35 403	42 289	45 757	47 431
- Unit consumption	lpcd	91	100	120	130	130	130
- Domestic consumption, h.c.	m^3/d	12 023	14 273	16 994	21 991	23 794	24 664
- Domestic, public tanks	m^3/d	887	1 050				
- Total domestic consumption	m^3/d	12 910	15 323	16 994	21 991	23 794	24 664
- Industrial consumption	m^3/d	2 964	2 500	2 800	2 800	2 800	2 800
- Commercial consumption	m^3/d	1 184	1 300	1 529	1 979	2 141	2 220
- Institutional consumption	m^3/d	1 668	1 700	1 699	2 199	2 379	2 466
- Other	m^3/d	335	350	350	350	350	350
- Total non-domestic	m^3/d	6 151	5 850	6 379	7 328	7 671	7 836
- Total water consumption	m^3/d	19 061	21 173	23 372	29 319	31 465	32 501
- Non-revenue water	%	56	50	37	31	28	25
- Non-revenue water	m^3/d	24 000	21 000	14 000	13 000	12 000	11 000
Average water demand	m^3/d	43 061	42 173	37 372	42 319	43 465	43 501
Max day demand	m^3/d	48 195	48 121	43 958	50 748	52 560	52 917

Projected Water Demand in the Augmented Area 3

Southeast of Ngo Quyen

		1 999	2 000	2 005	2 010	2 015	2 020
DONG HAI & DANG LAM							
- Population		26 295	26 558	32 754	38 933	44 727	51 516
- Service coverage (house conn.)		0	0	25	60	80	95
- Population served with h.c.		0	0	8 189	23 360	35 782	48 940
- Unit consumption	Lpcd	91	103	120	130	130	130
- Domestic consumption	m^3/d	0	0	983	3 037	4 652	6 362
DANG HAI & NAM HAI							
- Population		15 065	15 216	18 831	22 598	26 364	30 130
- Service coverage (house conn.)		0	0	10	20	40	80
- Population served with h.c.		0	0	1 883	4 520	10 546	24 104
- Unit consumption	Lpcd	91	103	120	130	130	130
- Domestic consumption	m^3/d	0	0	226	588	1 371	3 134
- Total population served with h.c.		0	0	10 072	27 879	46 327	73 044
- Total domestic consumption	m^3/d	0	0	1 209	3 624	6 023	9 496
- Total number of connections		0	0	2 014	5 576	9 265	14 609
- Industrial consumption	m^3/d	0	0	0	0	0	0
- Commercial consumption	m^3/d	0	0	60	181	301	475
- Institutional consumption	m^3/d	0	0	60	181	301	475
- Total non-domestic	m^3/d	0	0	121	362	602	950
- Total water consumption	m^3/d	0	0	1 329	3 987	6 625	10 445
- Non-revenue water	%	0	0	28	23	21	20
- Non-revenue water	m^3/d	0	0	517	1 191	1 761	2 611
Average water demand	m^3/d	0	0	1 846	5 178	8 386	13 057
Maximum day demand	m^3/d	0	0	2 333	6 601	10 730	16 736

Note: h.c. means house connection

Projected water demand in Le Chan district

		1 999	2 000	2 005	2 010	2 015	2 020
- Population in Le Chan		146 204	147 666	151 036	155 327	159 616	163 904
- Total population		146 204	147 666	151 036	155 327	159 616	163 904
- Population served with h.c.		141 818	143 236	148 015	153 774	159 616	163 904
- Service coverage (house conn.)	%	97	97	98	99	100	100
- Number of connections		38 674	33 311	36 547	38 443	39 904	40 976
- Unit consumption	lpcd	106	132	120	130	130	130
- Domestic consumption, h.c.	m^3/d	17 963	18 960	17 762	19 991	20 750	21 308
- Domestic, public tanks	m^3/d	11	12				
- Total domestic consumption	m^3/d	17 974	18 972	17 762	19 991	20 750	21 308
- Industrial consumption	m^3/d	823	810	900	900	900	900
- Commercial consumption	m^3/d	384	790	710	800	830	852
- Institutional consumption	m^3/d	1 331	1 500	1 332	1 499	1 556	1 598
- Other	m^3/d	200	200	200	200	200	200
- Total non-domestic	m^3/d	2 738	3 300	3 143	3 399	3 486	3 550
- Total water consumption	m^3/d	20 712	22 272	20 904	23 390	24 236	24 858
- Non-revenue water	%	25	24	28	28	28	27
- Non-revenue water	m^3/d	7 000	7 000	8 000	9 000	9 500	9 000
Average water demand	m^3/d	27 712	29 272	28 904	32 390	33 736	33 858
Max day demand	m^3/d	34 277	36 242	35 435	39 726	41 347	41 671

Table Projected Water Demand in the Augmented Area 2
South of Le Chan

		1 999	2 000	2 005	2 010	2 015	2 020
DU HANG KEHN							
- Population		22 801	23 029	28 739	34 046	38 776	43 473
- Service coverage (house conn.)		0	0	25	60	80	100
- Population served with h.c.		0	0	7 185	20 428	31 021	43 473
- Unit consumption	Lpcd	91	103	120	130	130	130
- Domestic consumption	m^3/d	0	0	862	2 656	4 033	5 651
VINH NIEM							
- Population		11 102	11 213	15 543	19 984	24 424	28 865
- Service coverage (house conn.)		0	0	50	80	90	95
- Population served with h.c.		0	0	7 772	15 987	21 982	27 422
- Unit consumption	Lpcd	91	103	120	130	130	130
- Domestic consumption	m^3/d	0	0	933	2 078	2 858	3 565
- Total population served with h.c.		0	0	14 956	36 415	53 002	70 895
- Total domestic consumption	m^3/d	0	0	1 795	4 734	6 890	9 216
- Total number of connections		0	0	2 991	7 283	10 600	14 179
- Industrial consumption	m^3/d	0	0	100	200	400	800
- Commercial consumption	m^3/d	0	0	90	237	345	461
- Institutional consumption	m^3/d	0	0	90	237	345	461
- Total non-domestic	m^3/d	0	0	279	673	1 089	1 722
- Total water consumption	m^3/d	0	0	2 074	5 407	7 979	10 938
- Non-revenue water	%	0	0	28	23	21	20
- Non-revenue water	m^3/d	0	0	807	1 615	2 121	2 734
Average water demand	m^3/d	0	0	2 881	7 022	10 100	13 672
Maximum day demand	m^3/d	0	0	3 618	8 908	12 833	17 344

note: h.c. means house connection

(2) Class B; Developing Area

1) Kien An

Haiphong Water Supply Company estimates that at the end 1999, it served about 25,700 people in Kien An through house connections and that the current service percent is about 36 % (through house connections). The service area covers the Kien An center and the main roads. The estimated service percentage is highest in Bac Son (53 %), Ngoc Son (about 51 %), Tran Thanh Ngo (47 %) Quan Tru (39 %) and Phu Lien (38 %). The service coverage is lowest in Dong Hoa phuong (3 %).

For 2A Water Supply Project feasibility study, it was assumed that all people will be served by 2020 in Tran Thanh Ngo, Ngoc Son, Quan Tru and Bac Son phuongs which can be considered as the urban areas of Kien An. It also predicted that in Phu Lien and Nam Son, about 80 % of the population would

be served in 2020, and about 60 % in Van Dau. The lowest service percent would be in Dong Hoa and Trang Minh (50 % in 2020) which are expected to remain partly rural farming areas.

A projection of estimated water demand in Kien An district is presented below.

Projected water demand in Kien An district

		1999	2000	2005	2010	2015	2020
-Total population		73 001	73 731	82 593	90 431	98 268	106 107
-Population served with h.c.		25 748	26 100	40 900	63 600	76 400	89 000
-Service coverage (house conn.)	%	35	35	50	70	78	84
-Number of domestic connections		8 399	8 500	10 487	16 308	19 590	22 821
-Unit consumption	lpcd	94	100	110	120	130	130
-Total domestic consumption	m^3/d	2 410	2 610	4 500	7 630	9 930	11 570
-Industrial consumption (6 % of domestic)	m^3/d	140	157	270	458	596	694
-Commercial cons. (2 % of domestic)	m^3/d	59	88	113	153	199	231
-Institutional consumpt. (growth 3 %/year)	m^3/d	1 071	1 035	1 190	1 370	1 580	1 820
-Total non-domestic	m^3/d	1 270	1 280	1 573	1 980	2 374	2 746
-Total water consumption	m^3/d	3 680	3 890	6 073	9 610	12 304	14 316
-Non-revenue water	%	74	73	60	38	27	20
-Non-revenue water	m^3/d	10 500	10 500	9 000	6 000	4 500	3 600
Average water demand	m^3/d	14 180	14 390	15 073	15 610	16 804	17 916
Maximum day demand	m^3/d	15 151	15 432	16 805	18 479	20 517	22 240

2) Do Son

Haiphong Water Supply Company estimates that the end of 1999, supplied water to about 11,400 people in the Do Son area (through house connections). The service percent is about 37 % of the total population. In Do Son the share of commercial consumption is bigger than in other areas. In Do Son the commercial consumption has been nearly 80 % of domestic consumption due to the numerous hotels and restaurants in the area. Industrial growth is also anticipated to attract other services commercial water consumption in Do Son is therefore estimated to grow from the present 600 m^3/d to 850 m^3/d by 2020.

A projection of estimated water demand in Do Son town is presented below.

Projected water demand in Do Son town

		1 999	2 000	2 005	2 010	2 015	2 020
- Population, Do Son		30 560	30 807	33 580	36 262	38 944	41 626
- Population served with h.c.		11 307	12 323	16 790	29 010	33 102	37 463
- Service coverage (h. c.)	%	37	40	50	80	85	90
- Number of domestic connections		1 613	1 760	2 399	4 144	4 729	5 352
- Unit consumption	lpcd	61	80	100	110	120	130
- Total domestic consumption	m^3/d	691	606	1 679	3 191	3 972	4 870
- Industrial consumption	m^3/d	108	135	140	160	180	200
- Commercial consumption	m^3/d	525	704	700	750	800	850
- Institutional consumption	m^3/d	439	310	350	400	450	500
- Other	m^3/d	42	40	40	40	40	40
- Total non-domestic	m^3/d	1 114	1 189	1 230	1 350	1 470	1 590
- Total water consumption	m^3/d	1 805	1 795	2 909	4 541	5 442	6 460
- Non-revenue water	%	42	42	31	25	23	20
- Non-revenue water	m^3/d	1 307	1 300	1 300	1 500	1 600	1 600
Average water demand	m^3/d	3 112	3 095	4 209	6 041	7 042	8 060
Max day demand	m^3/d	3 465	3 426	4 920	7 293	8 580	9 924

3) Quan Toan Industrial Area

Quan Toan industrial area is mostly rural for the time being and there is no centralized water supply system, but Haiphong Water Supply Company is supplying water from Vat Catch water treatment plant for some existing factories that are located in the area. It is assumed that the service percentage of domestic water connections will continue to be low and it will increase to about 40 % by 2020. Industrial consumption has been estimated to increase from the present 300 m^3/d up to 2,000 m^3/d by 2020.

A projection of estimated water demand in Quan Toan industrial area is presented below.

Projected water demand in Quan Toan

		1 999	2 000	2 005	2 010	2 015	2 020
- Population		4 161	4 203	4 994	5 827	6 410	6 993
- Population served with h.c.		0	0	499	1 165	1 923	2 797
- Service coverage (house conn.)	%	0	0	10	20	30	40
- Number of connections		0	0	100	291	481	699
- Unit consumption	lpcd	91	103	120	130	130	130
- Total domestic consumption	m^3/d	0	0	60	152	250	364
- Industrial consumption	m^3/d	280	300	350	500	1 000	2 000
- Commercial consumption	m^3/d	0	0	15	44	72	105
- Institutional consumption	m^3/d	0	0	10	29	48	70
- Total non-domestic	m^3/d	280	300	375	573	1 120	2 175
- Total water consumption	m^3/d	280	300	435	724	1 370	2 538
- Non-revenue water	%			25	23	21	20
- Non-revenue water	m^3/d	0	0	145	216	364	635
Average water demand	m^3/d	280	300	580	941	1 734	3 173
Maximum day demand	m^3/d	308	330	638	1 051	1 934	3 518

(3) Class C; Sub-urban Area

1) Minh Duc

There is no centralized water supply system in Minh Duc area in the year 2000. On the north side of the planned new industrial area there are some existing factories, repair shipyards and residential areas. In the proposed industrial area there are three communes, a small oil terminal and a small shipyard. It is assumed that Minh Duc area will stay more or less rural and there have been thus far no signs of industrial development. Based on the present situation, it can be assumed that domestic service percent would be 50% by the year 2020.

In the Water Master Plan prepared by Urban Planning Institute and VIWASE the water consumption was forecasted to be 12,250 m^3/d by 2000 and 35,000 m^3/d by 2010. For the time being, the biggest water user in the area is Chinfon Haiphong Cement factory located on the north side of the proposed new industrial area. The factory is using water about 1,000 m^3/d and after a planned extension water consumption will be about 1,900 m^3/d. The factory has it's own raw water intake and water treatment plant, and therefore there is no demand for outside service now or in the near future.

Another notable water user in the area is the Pha Rung Shipyard Company, using water about 100 m^3/d. They also have their own facilities for water supply but the raw water quality is poor and the facilities are old, so there would already be a demand for outside water.

Based on the figures presented in the Water Master Plan, prepared by Planning Institute and VIWASE, and real consumption figures for 2000, the industrial water consumption can be estimated to be 3,200 m^3/d by 2010 and 5,200 m^3/d by 2020.

A projection of estimated water demand in Minh Duc industrial area is presented below.

Projected water demand in Minh Duc

		1 999	2 000	2 005	2 010	2 015	2 020
- Population		19 197	19 389	22 806	26 158	29 908	33 658
- Population served with h.c.		0	0	0	1 423	2 250	3 155
- Service coverage (house conn.)	%	0	0	0	5	8	9
- Number of connections		0	0	0	356	563	789
- Unit consumption	lpcd	91	103	120	130	130	130
- Total domestic consumption	m^3/d	0	0	0	185	293	410
- Industrial consumption	m^3/d	0	0	0	3 200	4 200	5 200
- Commercial consumption	m^3/d	0	0	0	240	560	640
- Institutional consumption	m^3/d	0	0	0	240	560	640
- Total non-domestic	m^3/d	0	0	0	3 680	5 320	6 480
- Total water consumption	m^3/d	0	0	0	3 865	5 613	6 890
- Non-revenue water	%				10	15	20
- Non-revenue water	m^3/d	0	0	0	400	850	1 380
Average water demand	m^3/d	0	0	0	4 265	6 463	8 270
Maximum day demand	m^3/d	0	0	0	4 698	7 097	9 062

2) Dinh Vu

The Dinh Vu Economic Zone Project (DVEZ) has been developed by the consortium of American Internal Group, Asian Infrastructure Development Company from Thailand and Internal Port Engineering and Management from Belgium. The three companies are developed the economic zone on a joint venture basis. For water supply service DVEZ has established Dinh Vu Water Supply Company, which is operating inside Dinh Vu Economic Zone area.

A projection of estimated water demand in Dinh Vu industrial area is presented below.

Projected water demand in Dinh Vu

		1999	2000	2005	2010	2015	2020
- Population							
- Population served with h.c.		0	0	0	0	0	0
- Service coverage (house conn.)	%	100	100	100	100	100	100
- Number of connections		0	0	0	0	0	0
- Unit consumption	lpcd	91	103	120	130	130	130
- Total domestic consumption	m^3/d	0	0	0	0	0	0
- Industrial consumption	m^3/d	0	10	1500	5 400	6 750	8 438
- Commercial consumption	m^3/d	0	0	0	0	0	0
- Institutional consumption	m^3/d	0	0	0	0	0	0
- Total non-domestic	m^3/d	0	10	1 500	5 400	6 750	8 438
- Total water consumption	m^3/d	0	10	1 500	5 400	6 750	8 438
- Non-revenue water	%		9	9	10	15	20
- Non-revenue water	m^3/d	0	1	150	600	1 200	2 100
Average water demand	m^3/d	0	11	1 650	6 000	7 950	10 538
Maximum day demand	m^3/d	0	12	1 800	6 540	8 625	11 381

3) New Development Area

Haiphong Water Supply Company is serving water to New Development area from Song He intake. The service area covers a narrow strip alongside Do Son road. The current service percentage only, about 10 % (some 100 houses) but this is assumed to grow to about 65 % by 2020 when new Hoa Binh intake and water treatment plant will be in operation.

A projection of estimated water demand in New Development area is presented below.

Projected water demand in New Development area

		1 999	2 000	2 005	2 010	2 015	2 020
- Population		12 280	12 403	17 237	21 216	25 197	29 179
- Population served with h.c.		552	1 240	2 586	7 426	12 599	18 966
- Service coverage (h. c.)	%	4	10	15	35	50	65
- Number of domestic connections		116	125	646	1856	3150	4742
- Unit consumption	lpcd	123	120	120	120	120	130
- Total domestic consumption	m^3/d	68	149	310	891	1 512	2 466
- Industrial consumption	m^3/d	200	257	321	402	502	627
- Commercial consumption	m^3/d	81	85	90	95	227	370
- Institutional consumption	m^3/d	38	40	42	89	151	247
- Total non-domestic	m^3/d	319	382	453	586	880	1 244
- Total water consumption	m^3/d	387	531	764	1 477	2 392	3 709
- Non-revenue water	%	75	75	75	19	14	12
- Non-revenue water	m^3/d	290	398	573	340	400	520
Average water demand	m^3/d	677	929	1 336	1 817	2 792	4 229
Max day demand	m^3/d	733	1 019	1 490	2 187	3 409	5 217

(4) Augmented Area

It has been assumed that between now and the target year, the urban city area will expand in the following areas, South of Hong Bang district to Nam Son and An Dong communes, South of Le Chan district to Du Hang Kehn and Vinh Niem communes:

Southeast of the city area to Dong Hai, Dang Lam, Dang Hai and Nam Hai communes.

The above mentioned areas are included in WSCO's mid-term and long-term plans.

A projection of estimated water demand in the effective study area is presented below.

Projected Water Demand in the Total Augmented Area

		1 999	2 000	2 005	2 010	2 015	2 020
- Population		96 159	97 121	120 724	144 183	166 336	189 441
- Population served with h.c.		2 191	2 213	33 748	81 637	121 398	170 061
- Service coverage (house conn.)	%	2	2	28	57	73	90
- Number of connections		0	0	6 750	16 327	24 280	34 012
- Unit consumption	lpcd	91	103	120	130	130	130
- Total domestic consumption	m^3/d	199	228	4 050	10 613	15 782	22 108
- Industrial consumption	m^3/d	0	0	100	200	400	800
- Commercial consumption	m^3/d	10	11	202	531	789	1 105
- Institutional consumption	m^3/d	10	11	202	531	789	1 105
- Total non-domestic	m^3/d	20	23	505	1 261	1 978	3 011
- Total water consumption	m^3/d	219	251	4 555	11 874	17 760	25 119
- Non-revenue water	%	53	46	28	23	21	20
- Non-revenue water	m^3/d	247	214	1 771	3 547	4 721	6 280
Average water demand	m^3/d	467	464	6 326	15 421	22 481	31 398
Max day demand	m^3/d	563	568	7 971	19 616	28 674	40 065

note: h.c. means house connection

(5) Total Water Demand

The total average water demand has been calculated from the total average water consumption and non-revenue water. Consumption variations were taken into account using peak day and peak hour factors.

The Vietnamese sector standards recommend that the peak day coefficient K_d is 1.2 - 1.4, and the peak hour coefficient K_h is 1.5-1.6 for a community like Haiphong. In Water Supply Development Plan (WSDP 1992), the following figures were used:

K_d = 1.35 for domestic use and 1.1 for other use

$K_h = 1.5$

According to Haiphong WSCO, the maximum daily water production was about 1.2 times the average production in 1999. This corresponds well with the Water Supply Development Plan (WSDP) (1992) estimate. No information is available for the hourly variations. The figures recommended by WSDP were used when estimating the consumption variations. When calculating the peak day consumption, the average water consumption was multiplied by the peak daily coefficient of 1.35 for domestic use and 1.1 for other use. The table below shows the estimated total average water demand and maximum daily demand in 1999 and projections for 2000 – 2020 in the study area. These figures will be used as a basis for sizing facilities in he remainder of this Master Plan. Considering the stable rainfall and rich water surroundings of Haiphong such as Cam River and Lach Tray River, there are enough water resources to meet the future water demand.

Projected total water demand in Haiphong in 1999-2020

Water demand (m^3/d)	1999	2000	2005	2010	2015	2020
Domestic consumption	37 156	43 374	57 053	78 645	91 082	103 167
Industrial consumption	6 780	6 707	9 681	19 319	24 628	29 959
Commercial consumption	3 104	3 858	4 625	6 099	7 321	8 199
Institutional and other consumption	7 223	7 000	7 945	9 949	11 309	12 392
Total water consumption	54 263	60 940	79 305	114 012	134 340	153 718
Non revenue water	52 345	49 423	42 439	42 103	42 635	43 614
Total average demand	106 608	110 352	121 743	156 116	176 975	197 381
Maximum day demand	121 113	127 050	143 015	184 232	208 152	232 588

The table below shows the average and maximum daily water demand for the different service areas of WSCO.

Projected water demand by areas in Haiphong in 1999-2020

Water demand (m3/d)	1 999	2 000	2 005	2 010	2 015	2 020
Class A; Urbanized area						
Hong Bang [4]	17 119	19 718	26 293	31 312	34 508	36 438
South of Hong Bank[5]	467	464	1 599	3 221	3 995	4 669
Le Chan	27 712	29 272	28 904	32 390	33 736	33 858
South of Le Chan[6]	0	0	2 881	7 022	10 100	13 672
Ngo Quyen	43 061	42 173	37 372	42 319	43 465	43 501
Southeast of Ngo Quyen[7]	0	0	1 846	5 178	8 386	13 057
Total average demand	88 359	91 627	98 895	121 442	134 190	145 195
Total max day demand	101 456	106 831	117 362	143 984	157 990	171 247
Class B; Developing area						
Kien An	14 180	14 390	15 073	15 610	16 804	17 916
Do Son Town	3 112	3 095	4 209	6 041	7 042	8 060
Quan Toan	280	300	580	941	1 734	3 173
Total average demand	17 572	17 785	19 862	22592	25 580	29 149
Total max day demand	18 924	19 188	22 363	26 823	31 031	35 681
Class C; Sub-urban area						
Minh Duc				4 265	6 463	8 270
Dinh Vu		11	1 650	6 000	7 950	10 538
New Dev. Area	677	929	1 336	1 817	2 792	4 229
Total average demand	677	940	2 986	12 082	17 205	23 037
Total max day demand	733	1 031	3 290	13 425	19 131	25 660
Grand total average	**106 608**	**110 352**	**121 743**	**156 116**	**176 975**	**197 381**
Grand total max day	**121 113**	**127 050**	**143 015**	**184 232**	**208 152**	**232 588**

[4] Includes Nomura industrial area
[5] Augmented Area 1
[6] Augmented Area 2
[7] Augmented Area 3

2.4 Review of the Existing Plans

2.4.1 Haiphong Water Supply and Sanitation Programme, HPWSSP

(1) Objectives and Content

Haiphong Water Supply Company has received financial and technical support from the Finnish Government since 1990 for necessary investment, improvement and extension of the water supply system and long term development programs. Goals and achievements of each phase of HPWSSP are summarized below.

(2) Phase I, from January 1991 to March 1993.

Phase I of the Programme was called "Engineering and Management Study" and included the following main outputs:

- Preparation of water supply master plan for Haiphong City up to year 2010
- Implementation of a program for immediate repairs, data collection and development of most essential water supply materials manufacturing
- Preparation of an Organization and Manpower Development Plan for Haiphong Water Supply Company
- Preparation of a Commercial Plan for Haiphong Water Supply Company
- Preparation of a Project Document for the preparation of Haiphong Sanitation Master Plan
- Preparation of a Feasibility Study for the rehabilitation and extension of An Duong water treatment plan

During the Phase I it was discovered that the main technical problem of water supply in Haiphong was the high unaccounted-for water amount, a lot of which seems to be caused by institutional rather than purely technical reasons. On the other hand, it was revealed that without proper management practices, rehabilitation of water treatment plants and network construction would not help the water supply situation in the long run. Recommendations for the next phase were to focus the main physical effort on the above mentioned issues.

(3) Phase II, from April 1993 to June 1997.

The general objectives of the program were to provide the most affordable water supply service in urban center of Haiphong, to increase the independence of WSCO, and to improve the efficiency, quality of operations and economical performance of WSCO.

During phases I and II, the program has achieved a remarkable evolution in the development of the Haiphong water supply. Water quality and availability to

consumers has increased significantly. The operational and financial result of WSCO has also increased to a level that water supply could be developed by external loan financing, which the water company would now have he means to pay back through it's own revenue.

The main inputs in the implementation of HPWSSP were aimed at rehabilitation of the water transmission and distribution systems. The implementation strategy was geared towards a rapid increase of water revenue by establishing a maximum possible number of metered households connections and metered public tanks, the latter gradually subject to abandonment in favor of direct house connections.

The access of the population to the city water supply system increased considerably during the phase. Whereas 20 people had to share a water connection in the beginning, the corresponding indicator at the end of the phase was 6.3, indicating that ¾ of all households have their own connection to the system. The population depended on collective taps or tanks has consequently decreased from 332,000 to 127,000 and the number of persons per collective water point decreased from 706 to 339. Intermittent supply of water was also cut down to half and average pressure level in the urban network increased from 0.1 bar to 1.2 bar. The quality of water generally meets the Vietnamese standards and WHO guidelines.

(4) Phase III, from July 1997 to December 2000

Phase III is currently in progress with the main objective being to provide technical assistance in order to improve WSCO's management, support WSCO in implementation of Project 1A, and preparation of pre-feasibility and feasibility studies for a water supply project for the Kien An district and Vat Cach. During Phase III, four studies based on the Terms of Reference provided by the World Bank have been carried out by HPWSSP.

1) Consumer Services, Billing, Collection and Accounts Receivable

The objectives of the Billing and Collection were as follows:

- Update and maintain plans and maps identifying all existing and future customers on the ground, with a clear geographical codification
- Upgrade system to supply accounts and consumer service offices with detailed up-to-date customer information clearly specifying the category, type, size of connection, and the size, location and individual number of the water meter

- Review and upgrade for the systematic metering of non-metered connections and the rehabilitation of detective connections including faulty meters
- Identify sources of loss of revenue faulty meters and illegal or unrecorded connections
- Improve the customer services and customer relations duties including new agreements, new connections, changes and closures of connections
- Organize monthly meter reading to ensure that accurate data is submitted to the accounts and customer service offices
- Make recommendations on organizing collection of overdue debts
- Collaborate with the accounts and consumer service offices in disconnections and reconnections
- Review staff levels and abilities and recommend training programs for all field customer services staff
- Make recommendations on tools, equipment and stock levels that should be held to maximize the field activities

2) Non-Revenue Water Identification Pilot Program

The general objectives of the study were:

- To identify the components of NRW in the high-pressurized network area, which has already been rehabilitated by HPWSSP, in order to minimize the losses to manage them better in future
- To find out how to reduce NRW in an economically sound manner; and enable WSCO to be able to identify NRW components and learn techniques for better NRW management in the future

The detailed set of objectives of the Non-Revenue Water Identification Pilot Program as indicated in terms of reference of the study are as follows:

- Identify two suitable target areas (one located in the early rehabilitated phuongs and one in the recently rehabilitated area) with between 500 and 800 service connections where structured and comprehensive studies and monitoring can be undertaken to quantify water sold and non-revenue water
- Assess the potential institutional, financial, legal, and economic measures to implement: a) the replacement of faulty meters with more precise ones, b) replacement of spaghetti connections with tertiary network, and c) detection and repair of leaks

- Design a budget, timetable, and step-by-step action plan to implement effective and efficient reduction of non-revenue water, which are to be agreed upon by WSCO
- Supervise a) the procurement and installation of more precise meters, and b) comprehensive leak detection and repair programs
- Continuously monitor objectives through two period and appropriately fine tune the non-revenue water identification pilot program
- Evaluate the impacts of the measures to reduce non-revenue water, and evaluate the incremental costs and savings to the company
- Estimate the future projected economic savings with a delay and decrease in future water supply system investments
- Based on these results, design policy recommendations, a step-by-step action plan, a budget and a timetable for an effective and efficient non-revenue water reduction program for implementation on a city wide level

3) Study on Protection of Water Sources and Water Supply System

The main objective of the study was the protection of water quality in raw water intakes and in water supply facilities including treatment plants, raw water mains and the distribution network in WSCO's supply area.

The Study consisted of two tasks: Preparation of Action Plan (Land Use Component) and Review of Water Quality Monitoring (Water Quality Component including separate Water Quality Report).

The targets of the study were to:

- Clarify exact locations of water supply facilities on maps
- Strengthen the right of WSCO to use the area of water supply facilities
- Determine protection zones around water supply facilities according to the prepared zoning plan and the Vietnamese regulations
- Clarify and strengthen responsibilities and co-operation of authorities concerned
- Prepare emergency instructions for intakes, water treatment plants and booster pumping stations
- Evaluate the existing water quality monitoring program and water quality data
- Upgrade the water quality monitoring program

- Prepare a proposal to strengthen water quality management in WSCO

4) Operation and Maintenance Guidelines

The main objective of the study was to 'organize' a reasonably detailed analysis and description of the necessary O&M activities in physical and monetary terms in order to establish baseline data for:

- Preparing plans for Operation and Maintenance activities
- Measuring performance of various sections
- Measuring performance of entire water works
- Preparation of realistic O&M annual budged

In addition to the above-mentioned studies, one of the major management development components of the Phase III project has been the implementation of a Customer Network Management System (CNMS). This is GIS based system for storing and processing all relevant data of the network. It contains:

- physical network parameters (locations of pipes, valves and pressure meters, and water meters) collected from existing maps and drawings adequately georeferenced
- attribute data, such as characteristics of various components (pipe material, dimensions, year of construction etc.) collected from drawings and specifications
- network performance data i.e. metered consumption collected through the new billing system, where the meter reading data will be fed to

The system has been commissioned gradually starting from the already improved phuongs and some communes. The target is to feed in the entire water supply network of urban Haiphong upon completion of the 1A Water Supply Project. In the first stage, CNMS will be adopted for daily use in 18 improved phuongs.

(5) Water Supply, Drainage, Sewerage and Sanitation Management Programme in Haiphong

The Programme is divided into two parts: technical assistance and costruction management consultancy (CMC). The overall objective of the technical assistance of the Programme is: Good water supply and sanitation service for the people and customers in Haiphong as well as improved quality of the environment. The purpose of the Programme is to improve the performance of the water supply and sanitation organizations towards well functioning and financially

self-sustaining public enterprises. This purpose is fully consistent with, and supports, the National policies for urban water supply and urban wastewater collection and sanitation. The results expected from technical assistance of the Programme are:

- Strengthened management of all three companies
- Improved financial administration of all three companies
- Improved financing structure of all three companies
- O&M procedures of all three companies
- Selected households have improved their sanitary facilities with financing support that has been provided

The Construction Management Consultancy services will be financed by a grant from the Government of Finland and local parallel financing to be provided by Haiphong People's Committee. The objective of the CMC is to ensure that there is professional supervision of the projects construction component by an independent engineering firm experienced in administering major and complex contracts. The result expected from this component is that construction of the WB/IDA funded investment project (1B Project) is professionally well managed.

The management program started at the beginning of 2001 and will continue until end of 2004.

(6) 1A and 2A Water Supply Project

The most important existing projects are 1A Water Supply Project, financed through an IDA credit from the World Bank (Haiphong Water Supply and Environment Project, Stage 1A) and proposed 2A Water Supply Project (Haiphong Water Supply and Environment Project, Stage 2A) which is at the Feasibility study stage. Time schedules of the most important on-going water supply and related projects and plans are presented below.

General Schedule of On-Going Related Activities

COMPONENT	1998	1999	2000	2001	2002	2003	2004	2005	2006
Haiphong Water Supply and Sanitation Programme Phase III and Phase IV									
Design Consultancy for 1A									
Construction Period for 1A Project									
Construction Management Consultancy For 1A Project									
Detailed Designs and Contract Preparation Consultancy for Three Cities Sanitation Project, Haiphong Sub-Project (1B Project)									
Tentative Construction Period for 1B Project									
Construction Management Consultancy for 1B Project									
Feasibility Study of 2A									
Approval of the Feasibility Study of 2A									
Detailed design of 2A									
Construction Period for 2A									
Construction Management Consultancy For 2A Project									

2.4.2 Outline of the 1A FINNIDA / WB project

(1) Service Area (Figure 2.4.1 shows the service area)

The Haiphong 1A Water Supply Project will include investments with an IDA credit from the World Bank. The Feasibility study for 1A Water Supply Project was prepared by Soil and Water Ltd during 1995 and the final report published in November 1995. The implementation of the project started in June 1999, when the contract became effective. The contract for supply of plant and equipment was signed in March 1999 and the project is expected to be completed by the end of 2002. The 1A Water Supply Project will improve the capacity of the An Duong treatment plant, raw water supply to the An Duong plant and transmission and distribution systems in the urban center. The major part of the investment is targeted at network components and only minimal investments are allocated to water production. A New transmission main (diameter 300 to 400 mm) will be constructed between the town center and Vat Cach.

The phuong model improvement will include 15 phuongs in the urban center, which have not yet been included in improvement programs of HPWSSP or WSCO. The design year for the 1A Water Supply Project is 2010. Site supervision for the 1A Water Supply Project is financed by IDA credit. In addition to the

construction works, the project includes supply of vehicles, spare water meters and minor O&M equipment.

(2) Estimated Water Demand and Assumption

1) Domestic Consumption

In the beginning of 1995, water billing in Haiphong was mainly based on estimated use because only about 37 % of house connections had water meters. In October 1994, there were about 27,000 domestic house connections served by 110,000 people in the three urban districts.

The remaining approximately 300,000 inhabitants depended on water from public taps and public and collective ground tanks or taps of neighbours. Most of the drinking water to the area (about 80,000 m^3/d) was supplied from An Duong treatment plant.

In Kien An, there were about 3,700 private house connections in February 1995. According to WSCO, only about 11,000 people were served by house connections. In that time there were 6 public tanks in the area.

In Vat Cach area, the number of house connections was about 340 in October 1994, out which about 100 were in Hung Vuong, 40 in So Dau and 200 in Quan Toan. There were also 8 public tanks in Vat Cach area.

In Do Son, there were about 740 house-connections in February 1995 serving about 3,300 consumers. The priority consumers were the big business consumers, mainly hotels.

In February 1995 the total number of domestic house connections was 35,200. In addition to the domestic connections, there were about 740 industrial, institutional or similar connections.

In 1995, domestic water use increased from 93 lpcd to 407 lpcd while only 37 % of house connections had water meters. The estimated consumption of 19,000 m^3/d through house connections gave a specific consumption of about 155 lpcd when the figures given by WSCO were used.

2) Industrial Consumption

There was no reliable data for industrial water use available in the beginning of 1990. According to WSCO's estimation, industrial consumption in 1994 was about 7,000 m^3/d. HPWSSP has carried out some random measurements in the Water Use Study. The results show that water use per employee per day vary between 83 l and 830 l, being mostly between 336 l and 690 l.

It has been quite difficult to evaluate the reliability of figures for industrial water use in Haiphong before the metering program. A calculation of industrial water use on basis of the industrial labor force in 1990 suggests a use of about 280 liters per employee per day. According to the interview carried out in 1992, the average industrial consumption from the public network was 420 l/d per employee of which about 26% (107 lpcd) was used for sanitation or other domestic purposes. About 20% of total process water was cooling water.

3) Other Consumption

At the time that the 1A Feasibility study was prepared in 1995, institutional water consumption was about 20 % of total water consumption and total unaccounted for water was 69 % of the total water production.

(3) Planned System / Facility

1) Raw Water Supply

The An Duong water treatment plant has suffered from an inadequate raw water supply from time to time. A new raw water main transmission main will therefore be constructed from Quan Vinh to An Duong. The raw water main will be constructed along the existing road, and the length of the pipeline is about 3.7 km. The New raw water main will be constructed by DN 1000 mm pre-stressed concrete pipes.

Modification and extension works will be carried out at the Quanh Vinh pumping station to optimise the pumping efficiency. Some old pumps will be replaced by new ones with necessary accessories and electrical equipment.

2) Treatment Plants

To improve production capacity and water quality, An Duong treatment plant will be rehabilitated and expanded to a design capacity of 100,000 m^3/d. The water treatment plant upgrading consists of the following component :

- Modification of the second presedimentation lake to incorporate flash mixing of coagulant, mechanical flocculation and horizontal sedimentation
- Three indicating and recording flowmeters to record the inflow to each filter block
- Modification of phase II sedimentation tanks into conventional rapid sand filters

- Upgrading of the valves and controls of the existing phase II filters;
- New 2500 m^3 treated water reservoir
- Automatic priming system for backwash water pumps
- Renovating of the aluminium sulphate dosing system
- Second chlorinating station
- Upgrading of dirty backwash water discharge / recovery system

3) Water Distribution

In the distribution network, the main emphasis will be on improving service levels and reducing NRW. The capacity of transmission / distribution network is almost adequate up to the beginning of 2000. However the network is quite old, and maintenance has been limited, and the network is estimated to be in relatively poor condition. Based on the above, about 27 km of new transmission mains from DN 300 to DN 600 will be constructed. Pipe material will be ductile iron with cement lining.

Because the phuong rehabilitation model has been very successful in Haiphong, the rehabilitation of 15 new phuongs has been included in 1A Water Supply Project. The approach in the improvement of the phuong distribution system will follow the principles adopted from HPWSSP. There will be about 40,000 new house connections with new water meters in the 15 phuongs.

In May To phuong, a new 4,000 m^3 reservoir and booster pumping station will be constructed to supply water to a residential area and industrial zone in the north-east of the city.

4) Implementation Schedule and Cost Estimations

The proposed implementation schedule for the 1A Water Supply Project is shown in figure below.

Time schedule for 1A-Haiphong Water Supply and Environment Project

COMPONENTS	1994	1995	1996	1997	1998	1999	2000	2001	2002
Feasibility Study									
Detailed designs									
Bidding actions									
Mobilisation									
Implementation									
TA & Supervision									

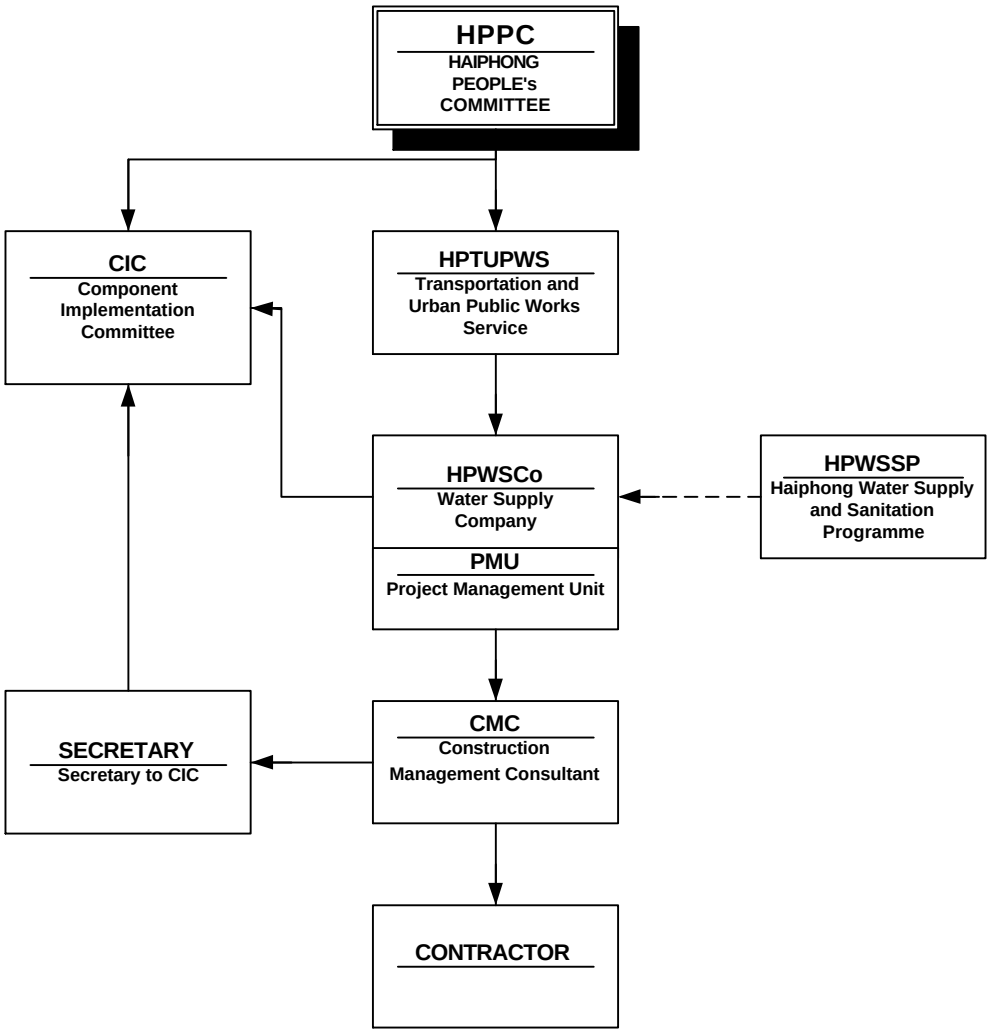
The estimated costs of the proposed investments are:

• Raw water supply	US$2.81 million
• Water treatment plant	2.73
• Water transmission and distribution	3.64
• Improvement of local distribution system (15 phuongs in city center)	5.64
• Water reservoir and booster station	0.82
• Network maintenance equipment	0.42
• Machinery and vehicles	0.68
• New office building	0.64
• Construction management	3.19
• Training and technical assistance	0.44
• Institutional support to WSCO	2.19
Total base cost	US$23.20 million

5) Planned Organizational Structure

Haiphong Water Supply Company has responsibility for the implementation of the components and its General Director has signed the project agreement with IDA. WSCO will be responsible for operation and maintenance of facilities through a contract with HPPC. The Project Management Unit (PMU) inside WSCO is managing the Project and settling all day-to-day issues in project implementation. Technical assistance for the project implementation is provided through the PMU. WSCO is the Employer, on whose behalf PMU is monitoring and controlling the contractors and suppliers and the efficiency and adequacy of the work of the Construction Management Consultant (CMC). WSCO will observe and follow resettlement, rules pay resettlement compensations and be responsible for protection of the environment during construction.

The approved organization structure for the 1A Water Supply Project is presented below:



2.4.3 Outline of Proposed 2A FINNIDA Project

(1) Area Covered (service area); Figure 2.4.2 Showing the Area

Haiphong 2A Water Supply Project covers some densely populated areas in urban districts, especially along new ring road and Kien An district. Besides that New Development area along Haiphong - Do Son road, An Dong area and Vat Cach area. A new raw water transmission main will be installed in the existing open channel between Quan Vinh intake and An Duong water treatment plant.

(2) Estimated Water Demand and Assumption

1) Domestic Consumption

Most of the water consumption is metered, so the consumption figures can be considered quite realistic. The average unit consumption through house connections is about 100 lpcd in the urban center and about 94 lpcd in Kien An and about 90 lpcd in Vat Cach. These figures are based on WSCO's

information about the number of persons in a household, which differs somewhat from the official statistics.

Experience in the improved phuongs, where all water consumption is measured, indicates that the domestic consumption through house connections varies between 90 lpcd and 120 lpcd when the connection is metered. To be on the safe side with the future water demand projections, the unit consumption is estimated to rise to 130 lpcd by 2020. All customers will be served through house connections (with a water meter) and no public supply is assumed. The domestic water consumption is the number of people served multiplied by the unit consumption.

2) Industrial Consumption

The present industrial water consumption is about 5,840 m^3/d in the urban center, about 140 m^3/d in Kien An, about 710 m^3/d in Vat Cach (including the Nomura industrial zone) and about 140 m^3/d in Do Son and along the Do Son road according to the contracts and billing of WSCO. For the water demand forecasts it is estimated that the industrial water consumption will be about 6,000 m^3/d in the urban center. No growth is expected because the tendency is to move all large industry from the urban center to industrial zones. In Kien An, industrial consumption is currently about 6 % of the domestic consumption, and the same proportion is also estimated in the future forecasts.

In the Vat Cach area, the industrial water consumption is forecasted to grow to about 2,000 m^3/d by 2020. In addition, the water consumption of the Nomura industrial zone is estimated to rise to 6,000 m^3/d by 2020. In 1998 the Nomura company requested from Haiphong WSCO 15,000 m^3/d as the maximum daily demand by 1998 (average demand about 13,500 m^3/d). However in 1998 the water consumption of the Nomura industrial zone was only about 530 m^3/d, and in 1999 it reduced to about 200 m^3/d. Therefore, Haiphong WSCO has recommended the use of a water demand estimate in future studies which is lower than that used in the earlier studies.

In Do Son and along the Do Son road, there is also potential for industrial growth. Industrial water consumption is estimated to grow to about 360 m^3/d by 2020 in these areas.

3) Other Consumption

According to WSCO's billing, commercial water consumption in the urban center is about 7 % of the domestic water consumption, and about 2 % in Kien An. The same proportion is used for future forecasts. In Vat Cach and

Do Son the share of commercial consumption is bigger. In Do Son, the commercial consumption has been nearly 80 % of domestic consumption due to the numerous hotels and restaurants in the area. The industrial growth is anticipated to attract also other services, therefore the commercial water consumption is estimated to grow from the present 310 m^3/d to 800 m^3/d by 2020 in Vat Cach and from 600 m^3/d to 860 m^3/d in Do Son.

Institutional water consumption includes hospitals, schools etc. According to WSCO's billing, institutional water consumption in the urban center is about 15 % of the domestic consumption. This share is assumed to remain about the same also in the future. In Kien An, the share of institutional consumption is much higher (about 40 %) compared to the domestic consumption. This is due to the high number of schools, universities and hospitals in Kien An, compared to the quite limited coverage of domestic water supply. In the future, the institutional water consumption is estimated to grow about 3 %/year in Kien An.

4) Non-Revenue Water

The estimated non-revenue water in 2A Project is the same as the estimate in this Study (see Section 2.3.1 (5)).

5) Water Treatment and Raw Water Supply

The distances between various urban zones of Haiphong, namely, the urban center, Kien An, Quan Toan and Do Son are long, about 10 km each (Do Son about 20 km). Therefore the costs related to construction of transmission mains between the zones are also high, and the selection of the best option for water treatment extension heavily depends on the area-wise distribution of the forecast water demand in 2020.

Based on above it has been chosen to keep separate water production between zones. The proposed water treatment and raw water supply components for 2A Water Supply Project are follows:

- Construction of new water treatment plant at Hoa Binh channel (10,000 m^3/d)
- Cau Nguyet water treatment plant rehabilitation (20,000 m^3/d)
- New transmission main from Quan Vinh raw water intake to An Duong water treatment plant
- Construction of new treated water reservoir at An Duong (4,000 m^3)

6) Water Transmission and Distribution

The design horizon in 2A Project is the year 2020, and the capacity of the water distribution network should be adequate at least to the year 2020.

The adequacy of the existing main pipes and the need for new transmission mains and distribution mains to be included in the 2A Water Supply Project has been assessed with network modeling. The network model prepared by HPWSSP was used as the basis of modeling. The model was prepared in 1996 and encompassed the urban center area. The model has been updated during this Feasibility Study to include the pipelines laid after 1996 and the pipelines in the 1A Water Supply Project (to be constructed in 1999 –2002). The Vat Cach distribution area has been added to the model of the urban center, and a separate model has been prepared for the Kien An distribution area. The network model includes the main transmission lines and distribution network with pipes bigger than or equal to 150 mm.

The proposed water transmission and distribution components for 2A Water Supply Project are follows:

- Kien An transmission mains, 12 km
- Kien An distribution pipes and consumer connections (13,000 house connections)
- City center transmission mains alongside the ring road, 12 km
- City center distribution pipes and consumer connections (14,000 house connections)
- Do Son road transmission mains, 7 km
- Do Son road distribution pipes and consumer connections (1,000 house connections)
- Vat Cach transmission mains, 5 km
- Vat Cach distribution pipes and consumer connections (3,500 house connections)

(3) Implementation Schedule and Estimated Cost

The 2A Water Supply Project is anticipated to be implemented in 2004-2006. The implementation schedule depends on the preceding activities, like approval by the Vietnamese authorities and the financiers. Detailed design and implementation will follow when all necessary approvals have been received. The proposed implementation schedule for the 2A Water Supply Project is shown in the figure below.

Preliminary time schedule for 2A Water Supply Project and related Activities

COMPONENT	1999	2000	2001	2002	2003	2004	2005	2006
Feasibility Study								
Identification of financing sources								
Approval of the Feasibility Study								
Detailed designs								
Bidding actions								
Implementation								
TA & Supervision								

The estimated costs of the proposed investments are:

• Water treatment and raw water supply	US$5.10 million
• Water transmission and distribution	14.35
• Unallocated cost	1.15
• Auxiliary support material and services	0.50
• Construction management	2.50
• Training and technical assistance	0.60
• Employer's cost	0.40
Total base cost	US$24.60 million

(4) Organizational Recommendations

The proposed organization structure will be similar to the one proposed in 1A Water Supply Project (see Section 2.4.2).

2.4.4 Outline of Existing Water Supply Master Plan for Water Supply Development for the Future

Haiphong City Water System Master Plan 2010 was prepared in 1995 by Haiphong Planing Institute and Vietnam Institute for Water and Sanitation Engineering (VIWASE). The Draft Final Report was published in June 1995 but it has not been translated into English.

The Planning Institute, in co-operation with VIWASE and the WSCO, completed the Master Plan for the Urban Water Supply System in 1997. The target year for this plan is 2010. This plan consists of three volumes and has several maps as attachment. The maps used were at a scale of 1:5,000-1:25,000 and 1:50,000-1:100,000.

In the Water System Master Plan the following Water Treatment Plants are mentioned:

- An Duong Water Treatment Plant 135,000-175,000 m^3/d in 2010.
- Vat Cach Water Treatment Plant 21,000- 40,000 m^3/d in 2010.
- Cau Nguyet Water Treatment Plant 16,000- 25,000 m^3/d in 2010.
- Minh Duc Water Treatment Plant 13,500- 55,000 m^3/d in 2010.
- Phan Dung Water Treatment Plant 35,000-125,000 m^3/d in 2010.

Lately all detailed design projects and all feasibility studies have used smaller water demand figures than those stated in Haiphong City Master Plan and Haiphong Water System Master Plan because development in Haiphong has proceeded much more slowly than was estimated in those Master Plans. The use of smaller water demand figures has been agreed with WSCO.

2.5 System and Facility Measures

2.5.1 Targets and Principles for Improvement

(1) Service Area

Access to safe drinking water is a fundamental need of people in Haiphong. Hence, the target is to cover the entire Effective Study Area with the water supply network by 2020 (see Figure 2.5.1). This includes 4 urban districts (Hong Bang district, Ngo Quyen district, Le Chan district and Kien An district), Augmented Area around urban districts, Do Son District, New Development Area, Minh Duc area, planned industrial areas Quan Toan, and Dinh Vu.

(2) Demand and Quality

The water quality targets have been set in Corporate Plans of WSCO, and the same target was adopted in this Study. The general target is that water quality at customer's taps meets the requirement of Vietnamese domestic water standard.

(3) Ratio of Unaccounted Water

Out of the total water production of Haiphong Water Supply Company (WSCO), 50.3 % was sold and 49.7 % was non-revenue water by 1999. Non-revenue water was attributed to leakage, inaccurate or non-working water meters, meter reading and billing errors, and unknown or non-defined losses.

When the transmission and distribution system is improved in all distribution areas, the share of non-revenue water should be reduced to about 20-25 % of the total water production by 2020 as estimated in the section on water demand (see Section 2.3.1)

(4) Existing Projects/Plans

In working out the water supply improvement plan the current Study, the plans recommended in the WB/FINNIDA 1A and 2A Projects were duly studied and considered as a given condition for the Study. Some additional plans were formulated by the Study for areas which were not covered by the World Bank/FINNIDA projects.

2.5.2 Alternatives and Selection of Optimum Measures

(1) Class A Area; City Center

In the City Center, the target is to rehabilitate all as yet unimplemented parts of the distribution network, increase house connections to 100 %, increase the capacity of An Duong water treatment plant, increase reservoir capacity in the city center, improve raw water supply capacity and reliability and continue development of

the SCADA system. The following works have been designed or are planned to be implemented by 2020 in the 1A and 2A Water Supply Projects or as part of the normal works program of WSCO:

- Expanding of transmission mains in city center area
- Rehabilitation of An Duong WTP Phase I
- Construction of May To booster pumping station and reservoir 4000 m^3
- Rehabilitation of Quan Vinh raw water intake
- Construction of new raw water main I Quan Vinh-An Duong
- Rehabilitation of distribution network in phuongs (13 phuongs, 100 % coverage)
- Finalising SCADA system
- Expanding transmission mains and distribution network in Vat Cach-Quan Toan, and Hung Vuong areas
- Expanding transmission mains, distribution pipes and house connections along ring road in the southern part of City Center
- Expanding reservoir capacity by 4000 m^3
- Construction of new raw water transmission pipe II Quan Vinh–An Duong W.T.P.
- Expanding distribution network
- Extension and rehabilitation of An Duong WTP Phase II
- Construction of new reservoir capacity. II

(2) Class B Area; Do Son, Kien An, Quan Toan

In Class B area the target is to reduce high UFW percentage in Kien An, expand network and house connections, increase existing water treatment capacity and construct a new water treatment plant for Do Son and New Development area. The following works have been designed or are planned to be implemented by 2020, mostly through the 2A Water Supply Project:

- Installing new house connections and consumer water meters
- Expanding transmission mains, distribution pipes and house connections in Kien An
- Rehabilitation of Cau Nguyet water treatment plant
- Construction of new Hoa Binh intake and water treatment plant
- Expanding distribution network
- Extension and rehabilitation of Vat Cach water treatment plant

- Modification of Do Son water treatment plant for booster pumping station (one new reservoir 5,000 – 10,000 m^3)
- Expanding and rehabilitation of the distribution network
- Extension of Hoa Binh water treatment plant, phase II

(3) Class C Area; Minh Duc, Dinh Vu, New Development Area

Dinh Vu water supply is managed by the Dinh Vu Water Supply Company DVWSCO) owned by Dinh Vu Development Joint Venture Co. Ltd. DVWSCO will design and implement all water supply projects inside Dinh Vu island.

Minh Duc water supply development depends entirely on industrial development in proposed industrial area. Therefore Dinh Vu management style is proposed to be used for water supply implementation also in Minh Duc.

New Development area has developed rapidly and this is assumed to continue in coming years. Water supply in the area will be developed together with Do Son town by installing new transmission and distribution pipes, construction of a new water treatment plant and increasing the numbers of houses connected to the water network.

Following works have been designed or are planned to be implement by 2020:

- Installing new house connections and consumer water meters for New Development area
- Expanding water supply inside Dinh Vu Economic zone area (DVWSCO task)
- Construction of new transmission main, distribution pipes and house connections alongside Do Son road between Song He- Cat Bi
- Hoa Binh water treatment plant
- Construction on raw water intake for Minh Duc
- Constructions on raw water intake and water treatment plant Minh Duc
- Construction on transmission mains and distribution network for Minh Duc
- Expanding distribution network
- Expanding distribution network
- Constructions on new reservoir capacity, phase II

2.5.3 Preliminary Design and Cost Estimation for the Optimum Measures

(1) Preliminary Design of the System and Facility

1) Class A

Current works underway are the implementation of the City center network rehabilitation, An Duong water treatment plant, May To booster station construction, Quan Vinh raw water intake rehabilitation and new raw water main construction.

A feasibility study is under preparation for the following components:

- Expanding transmission mains and distribution network in Vat Cach-Quan Toan, and Hung Vuong areas
- Expanding transmission mains, distribution pipes and house connections along the ring road in the southern part of the City Center
- Expanding reservoir capacity by 4,000m^3 in An Duong
- Construction of new raw water transmission pipes Quan Vinh – An Duong

2) Class B

Feasibility study is under preparation for the following components:

- Expanding transmission mains, distribution pipes and house connections in Kien An
- Rehabilitation of Cau Nguyet water treatment plant
- Construction of new Hoa Binh raw water intake and water treatment plant

3) Class C

Feasibility study is under preparation for following components:

- Construction of new transmission main, distribution pipes and house connections alongside Do Son road between Song He- Cat Bi
- Construction of new Hoa Binh raw water intake and water treatment plant (partly for Do Son, partly for New Development area)

(2) Cost estimation

Cost estimations for initial investment cost, replacement cost and operation and maintenance costs are given in tables below:

Estimate of Project Cost for Water Supply Projects

Total Project Cost

(Unit: 1000 US$)

Item	Total
A. Construction Cost	
1) Hong Bang, Le Chan & Ngo Quyen area	33 662
(1) Civil Works	27 609
(2) Mecanical & Electrical Works	6 053
2) Quan Toan area	1 337
(1) Civil Works	1 120
(2) Mecanical & Electrical Works	217
3) Kien An area	4 759
(1) Civil Works	4 038
(2) Mecanical & Electrical Works	721
4) Minh Duc area	1 650
(1) Civil Works	1 398
(2) Mecanical & Electrical Works	252
5) Dinh Vu area	0
(1) Civil Works	0
(2) Mecanical & Electrical Works	0
6) New Development area	1 708
(1) Civil Works	1 415
(2) Mecanical & Electrical Works	293
7) Do Son area	2 081
(1) Civil Works	1 481
(2) Mecanical & Electrical Works	600
Total	45 197

The construction is to be implemented in two phases; Phase I and, Phase II, Construction costs and their breakdown are shown in Tables :

2) Project Cost for Phase I

(Unit: 1000 US$)

Item	Total
A. Construction Cost	
1) Hong Bang, Le Chan & Ngo Quyen area	26 962
(1) Civil Works	22 109
(2) Mecanical & Electrical Works	4 853
2) Quan Toan area	337
(1) Civil Works	337
(2) Mecanical & Electrical Works	0
3) Kien An area	4 044
(1) Civil Works	3 323
(2) Mecanical & Electrical Works	721
4) Minh Duc area	0
(1) Civil Works	0
(2) Mecanical & Electrical Works	0
5) Dinh Vu area	0
(1) Civil Works	0
(2) Mecanical & Electrical Works	0
6) New Development area	1 348
(1) Civil Works	1 105
(2) Mecanical & Electrical Works	243
7) Do Son area	1 011
(1) Civil Works	761
(2) Mecanical & Electrical Works	250
Total	33 702

3) Project Cost for Phase II

(Unit: 1000 US$)

Item	Total
A. Construction Cost	
1) Hong Bang, Le Chan & Ngo Quyen area	6 700
(1) Civil Works	5 500
(2) Mecanical & Electrical Works	1 200
2) Quan Toan area	1 000
(1) Civil Works	783
(2) Mecanical & Electrical Works	217
3) Kien An area	715
(1) Civil Works	715
(2) Mecanical & Electrical Works	
4) Minh Duc area	1 650
(1) Civil Works	1 398
(2) Mecanical & Electrical Works	252
5) Dinh Vu area	0
(1) Civil Works	0
(2) Mecanical & Electrical Works	0
6) New Development area	360
(1) Civil Works	310
(2) Mecanical & Electrical Works	50
7) Do Son area	1 070
(1) Civil Works	720
(2) Mecanical & Electrical Works	350
Total	11 495

2.5.4 Phased Development and Distribution Schedule

The phased development and distribution schedule for short term, middle term and long term target years and the annual disbursement schedule are given in Table 2.5.1,and Table 2.5.2.

2.6 Strengthening of Managing Organization and Manpower Training

2.6.1 Improvement of the Management and Operation and Maintenance

(1) Strengthening Autonomy and Management Decision Making of WSCO

In general, WSCO needs a range of strengthening measures, including more authority to negotiate an appropriate price for water, more control over personnel recruitment and salaries, more control over procurement, and greater ability to raise capital.

At present, WSCO through its PMU has the responsibility to repay the Ministry of Finance for the capital provided as part of World Bank Loan 1A. However, the WSCO has been unable to convince the HPPC to allow for the necessary gradual increases in the water tariff to provide the funds necessary for ultimate repayment. This is good example of where WSCO has a major responsibility without sufficient authority to discharge the responsibility.

As part of the Haiphong City government apparatus, WSCO is controlled by administrative and personnel policies of the Haiphong People's Committee. Restrictions on recruitment, salaries, and promotion make it difficult to recruit new staff with the necessary skills and to provide adequate incentives.

The success of WSCO in receiving financing for the World Bank 1A Water Supply Project, coupled with its capable management of the project, are evidence of the WSCO's ability to undertake major capital projects. However, the planning and approval process still requires that: 1) WSCO prepare the necessary project proposal; 2) then submit for TUPWS for review and comment before passing to HPPC for approval; and 3) finally HPPC making application to the Ministry of Finance. As more innovative financing arrangements become necessary (e.g. joint ventures, private sector participation, or BOT), WSCO will need more flexible mechanisms for obtaining investment.

(2) Reduction in Non Revenue Water

As previously defined, non revenue water is "water that is produced but not sold".

To reduce the amount of non-revenue water, the HPWSSP, has proposed:

- The implementation of active leakage control programs

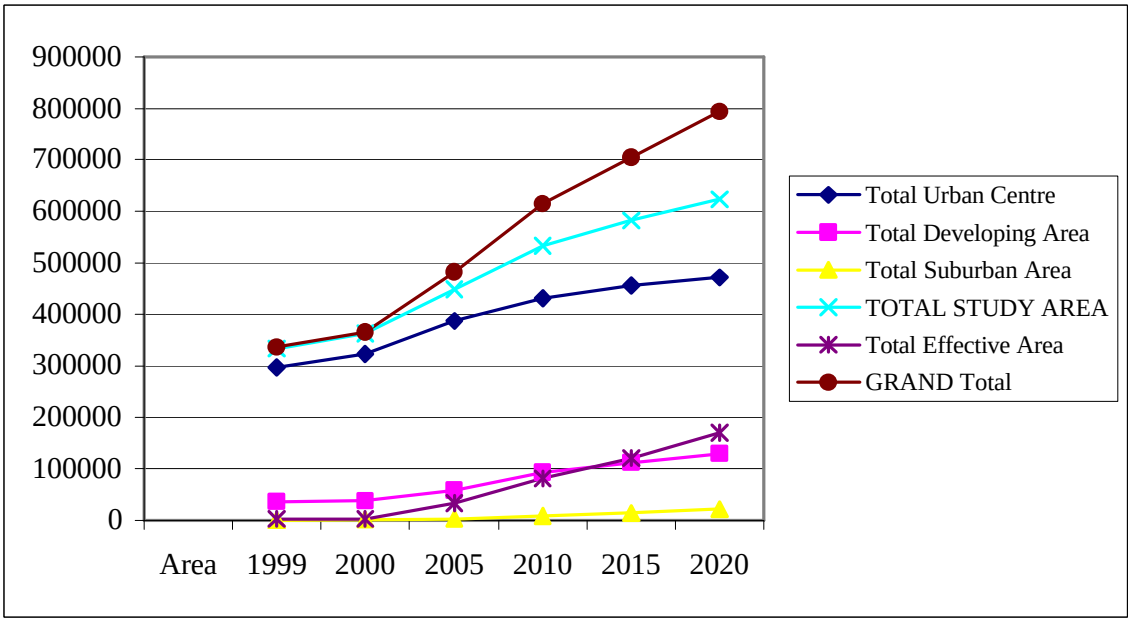
- Network operation and maintenance programs
- Network rehabilitation programs
- Maintenance and replacement of water meters

To effectively implement the non revenue water (NRW) reductions programs, the HPWSSP has proposed that the:

- Consumer Service Department (technical department)
  - Forms a team for leakage detection (already operational)
  - Monitors consumption and NRW in phuong networks
  - Controls the repair and replacement of the distribution network in cooperation with Network Department
- Water Meter Workshop
  - Be responsible for maintenance of water meters and be in control of the installation and replacement of waters meters
  - Implement the operation and maintenance practices in WSCO's Water Meter Policy
- Phoung Offices
  - Provide daily reports on all water meters not functioning properly
  - Provide weekly inspections as part of visual leak detection programs
  - Ensure that water meter readers inspect for leaks (before and after the meter)
- Network Department
  - Has a team for leak detection in the main network
  - Has a team for control of the flow and pressure in the network
  - Develops a network rehabilitation program in conjunction with the technical department and the planning department
  - Has a maintenance team for regular pipe cleaning and flushing

2.6.2 Demand for Water Services

Specific proposals for training to strengthen management, organization, and manpower in WSCO are based on the projections of the water supply demand and capital works projects that are being planned to meet the necessary increases in water supply.



Estimated Population Served by Household Connection

The long-term projection shows about 800,000 people served by household connections by 2020 compared with the current estimate of 336,370 people.

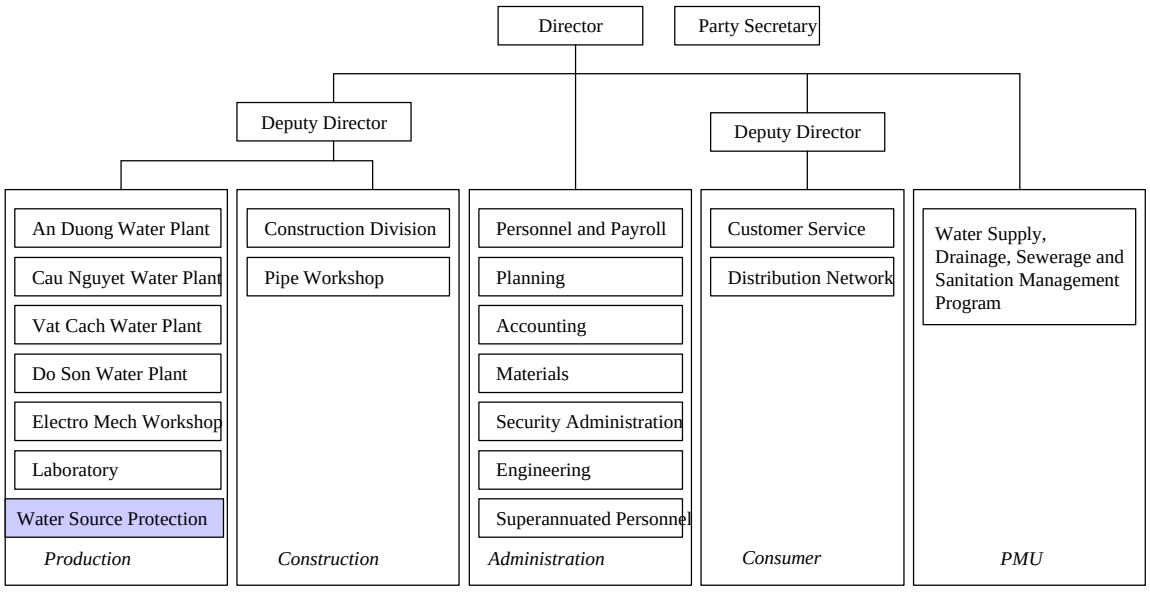
2.6.3 Organizational Changes

The WSCO organization structure requires little change, as the company has recently been reorganized. A second vice director has been recently recruited and has been given responsibility for the consumer sector. Depending on the timing of the 2A Project, the project management capability of WSCO will have to be strengthened (Table below).

In the near future, WSCO will increase its efforts to protect water sources and the water supply system. The main objective will be the protection of water quality at raw water intakes and in water supply facilities including treatment plants, raw water mains, and the distribution network. It is anticipated that work in this area will grow and a new unit will be needed as early as 2004. This unit will become part of the production department (Figure below).

Implementation Time Schedule

Time	Organizational Development Event
2002	▪ Creation / Strengthening of PMU for 2A Project
2004	▪ Creation of a unit for Water Source Protection



Organization Chart for WSCO showing new unit for Water Source Protection.

2.6.4 Manpower Estimates

The table below shows the simple assumptions used to estimate future staffing levels.

Current staff and assumption used to project future staffing levels

Unit	**2000 (estimated)**	**Assumptions used in Estimate of Future Staffing**
	3	Organizational structure and size
Production	268	WTP capacity Implementation of Non Revenue Water Programs
Construction	45	**Number of connections**
Administration	73	Organization size
Consumer	269	**Number of Connections** **Implementation of Non Revenue Water Programs**
WSDSSMP	18	**Program management needs**
Water Source Protection		30
TOTAL	676	

Source: WSCO Corporate Plan 2000

The staffing levels are expected to increase to 1601 people by 2000 (Table below).

Staffing levels projected to the year 2020

Staffing Projection					
	2000	2005	2010	2015	2020
Director Office	3	4	5	6	7
Production	268	414	520	591	662
Construction	45	64	82	94	106
Administration	73	107	135	155	173
Consumer	269	385	492	563	635
HPWSSP	18	18	18	18	18
Total	676	993	1253	1427	1601

2.6.5 Human Resource Development

(1) Corporate Plan 2000

The WSCO Corporate Plan outlines a number of management improvements to be implemented including:

- strengthening the autonomy of WSCO and upgrading management ability for implementation of World Bank 1A project
- increased capacity to prepare action and financial plans
- development of management information systems including the introduction of software to produce accurate monthly and quarterly reports
- development of a material management system
- improvement in phuong management

(2) Water Supply, Sewerage, Drainage, and Sanitation Management Program in Haiphong (2001-004) (WSSDSMP)

The WSSDSMP will assist WSCO in implementing most of the needed improvements. It is planning technical assistance on:

1) Company Management

The main institutional support will focus on:

- corporate management training
- billing, collection and accounting management, reporting and control

Specific aspects to be improved through technical assistance will include:

- development of management information systems
- development of material management systems
- improvement of logistics
- improvement of billing, collection, and accounting practices, improvement of reporting, and use to new technologies
- standardized operation and maintenance procedures
- occupational safety for operation and maintenance
- training of multipurpose team for repairs
- further development and utilization of geographic information systems
- identification of new financing sources for investments

2) Strengthening of Water Treatment Plants and Networks

- reduction and follow-up of non revenue water
- implementation of operation and maintenance programs
- upgrading of telemetry systems
- monitoring of water treatment plants
- upgrading of CNMS (Consumer and Network Management Systems)

3) Training and human Resource Development

- training on customer service and phuong management
- training on operation of computerized accounting systems
- other training

(3) Manpower Training

The Corporate Plan outlines specific training programs for the WSCO in the year 2000 (See Table below)

WSCO Training Programs 2000

	Training Course	Participants
1	Human Resource Management	1
2	Training in Management and Development	1
3	Study and Installation of Clear Water System	2
4	Establishment of Maintenance Services	3
5	Installation of CI pipelines and connecting pipes	7
6	Safety in Production	70
7	Upgrading PC Net Management Skills	2
8	Law and Policy Knowledge	40
9	Installation of PVC pipelines and connecting pipes	7
10	Grade Upgrading	150
11	Filter Technology	5
12	Financial Management	2
13	Project Reporting Skills	2
14	Managing Customer Services	2
15	Revenue Collecting Skills	70
16	Upgrading Meter Reading Skills	70
17	Upgrading Phuong Management skills	50
18	English Course	20
19	In- service Course	40
20	Use of new tools and Equipment	15
21	Operation and Maintenance Workshop	30
22	Course on Management and Treatment for Water Treatment Plants	30

(4) Basic Strategy for HRD

The basic human resource development strategy for WSCO is to:

- Strengthen the capacity of the project management unit (PMU) to ensure that it can effectively implement the capital investment projects
- Improve administrative efficiency throughout the organization
- Increase the technical competence of operations and maintenance staff to ensure sustainability of new system improvements
- Upgrading managerial skills to introduce modern management methods
- Introduce business planning methods to foster the development of the organization into an autonomous and commercially viable business entity

The sets of specific skills that must be developed to achieve these objectives are:

Specific Skills Required

Strategic Objectives	**Specific Skills**
Strengthening Project Management Units	• Project management skills • Financial management skills (planning and budgeting • Bidding and Contract Management • Engineering skills • Foreign Languages
Improving Administrative Efficiency	• Accounting • Billing and Collection Systems • Finance and Budgeting • Management Information Systems • Personnel Management and Training • Performance monitoring
Improving Operations and Maintenance Competence	• Production, construction, and consumer sectors
Upgrading of Management Skills	• Post secondary training – Master of Business Administration of Master of Public Administration or other executive programs
Business Planning	• Formal business plans designed at defining the core business • Characterizing of business opportunities – including revenue projections and cost estimates • **Planning for financing and the recruitment of staff to take advantage of the business opportunities**

Training for Operations and Maintenance

Sector	**Specific Skills**
Production	• Operation and maintenance of water treatment plants • non revenue water reduction programs • Monitoring water quality • Upgrading of telemetry system • **Monitoring of water treatment plants**
Construction	• Customer relations • Work orders and job costing
Consumer – Customer Service Department	• Customer relations • Marketing • Contracting • Meter reading • Collections • Inspection
Consumer - Network Department	• Network maintenance • Meter maintenance • Management of customer connections • Active leak detection and repair • Leak detection equipment • Seminar in non revenue water management

Table 2.5.1 Table of Phased Development Water Supply Development 2001 - 2020 (1/2)

	A: URBANIZED AREA CITY CENTRE AREA	B: DEVELOPING AREA DO SON, KIEN AN, QUAN TOAN	C: SUB-URBAN AREA MINH DUC, DINH VU, NDA
YEAR 2005	1.) Expanding of transmission mains in city centre area. (1A-Project) 2.) Rehabilitation of An Duong WTP Phase I (1A-Project) 3.) Construction of May To booster pumping station and reservoir 4000 m3 (1A-Project) 4.) Rehabilitation of Quan Vinh raw water intake. (1A-Project) 5.) Construction of new raw water main QV-AD. (1A-Project) 6.) Rehabilitation of distribution network in phuongs (15 phuongs, 100% coverage, 1A-Project) 7.) Finalising SCADA system. (HPWSSP)	1.) Installing new house connections and consumer water meters. (HPWSCo routine task)	1.) Installing new house connections and consumer water meters for NDA (WSCo routine task) 2.) Expanding water supply inside Dinh Vu Economic zone area. (DVWSCo task)

Table 2.5.1 Table of Phased Development Water Supply Development 2001 - 2020 (2/2)

	A: URBANIZED AREA CITY CENTRE AREA	B: DEVELOPING AREA DO SON, KIEN AN, QUAN TOAN	C: SUB-URBAN AREA MINH DUC, DINH VU, NDA
YEAR 2010 **Cont.**	1.) Expanding transmission mains and distribution network in Vat Cach-Quan Toan, and Hung Vuong areas (2A-Project) 2.) Expanding transmission mains, distribution pipes and house connections along ring road in the southern part of City Centre (2A-Project) 3.) Expanding reservoir capacity by 4000m3. (2A-Project) 4.) Construction of new raw water transmission pipe Quan Vinh – An Duong W.T.P. (2A-Project)	1.) Expanding transmission mains, distribution pipes and house connections in Kien An (2A-Project) 2.) Rehabilitation of Cau Nguyet W.T.P (2A-Project) 3.) Construction of new Hoa Binh W.T.P (2A-Project)	1.) Construction of new transmission main, distribution pipes and house connections alongside Do Son road between Song He- Cat Bi. (2A-Project) 2.) Hoa Binh W.T.P (2A-Project) 3.) Expanding water supply inside Dinh Vu Economic zone area. (DVWSCo task) 4.) Construction of raw water intake for Minh Duc 5.) Construction W.T.P. for Minh Duc. 6.) Construction transmission mains and distribution network for Minh Duc. 7.) Expanding water supply inside Dinh Vu Economic zone area. (DVWSCo task)
YEAR 2015	1.) Expanding distribution network. 2.) Extension and rehabilitation of An Duong WTP Phase II	1.) Expanding distribution network. 2.) Extension and rehabilitation of Vat Cach W.T.P 3.) Modification DSWTP-BPS (one new reservoir 5,000 – 10,000 m3)	1.) Expanding distribution network.
YEAR 2020	1.) Expanding and rehabilitation of distribution network. 2.) Construction of new reservoir capacity. II	1.) Expanding and rehabilitation of distribution network 2.) Extension of Hoa Binh W.T.P. II	1.) Expanding distribution network 2.) Construction of new reservoir capacity. II

Table 2.5.2 Annual Disburcement of Construction and Operation Costs for Water Supply (1/4)

Cost Component	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Construction Cost (1000 US$)
Water Supply											
A. Construction Cost											
1) Hong Bang, Le Chan & Ngo Quyen areas											26962
(1) Civil Works	3980	3095	223	4863	4863	5085					22109
(2) Mechanical & Electrical Works	874	679	47	1068	1068	1117					4853
2) Quan Toan area											337
(1) Civil Works						337					337
(2) Mechanical & Electrical Works											0
3) Kein An area											4044
(1) Civil Works				1107	1107	1109					3323
(2) Mechanical & Electrical Works				240	240	241					721
4) Minh Duc area											0
(1) Civil Works											0
(2) Mechanical & Electrical Works											0
5) Dinh Vu area											0
(1) Civil Works											0
(2) Mechanical & Electrical Works											0
6) New Development area											1348
(1) Civil Works				368	368	369					1105
(2) Mechanical & Electrical Works				81	81	81					243
7) Do Son area											1011
(1) Civil Works				253	254	254					761
(2) Mechanical & Electrical Works				83	83	84					250
Sub-Total	4854	3774	270	8063	8064	8677	0	0	0	0	33702

Table 2.5.2 Annual Disburcement of Construction and Operation Costs for Water Supply (2/4)

Cost Component	2011	2012	2013	2014	2015	2016	2017	2018	2019	20120	Construction Cost (1000 US$)
Water Supply											
A. Construction Cost											
1) Hong Bang, Le Chan & Ngo Quyen areas											6700
(1) Civil Works	1100	1100	1100	1100	1100						5500
(2) Mechanical & Electrical Works	240	240	240	240	240						1200
2) Quan Toan area											1000
(1) Civil Works	350	433									783
(2) Mechanical & Electrical Works	100	117									217
3) Kein An area											715
(1) Civil Works		200	315	200							715
(2) Mechanical & Electrical Works											0
4) Minh Duc area											1650
(1) Civil Works	200	398	350	250	200						1398
(2) Mechanical & Electrical Works		50	102	100							252
5) Dinh Vu area											0
(1) Civil Works											0
(2) Mechanical & Electrical Works											0
6) New Development area											360
(1) Civil Works			100	160	50						310
(2) Mechanical & Electrical Works				50							50
7) Do Son area											1070
(1) Civil Works			170	350	200						720
(2) Mechanical & Electrical Works				200	150						350
Sub-Total	1990	2538	2377	2650	1940	0	0	0	0	0	11495
Total											45197

Table 2.5.2 Annual Disburcement of Construction and Operation Costs for Water Supply (3/4)

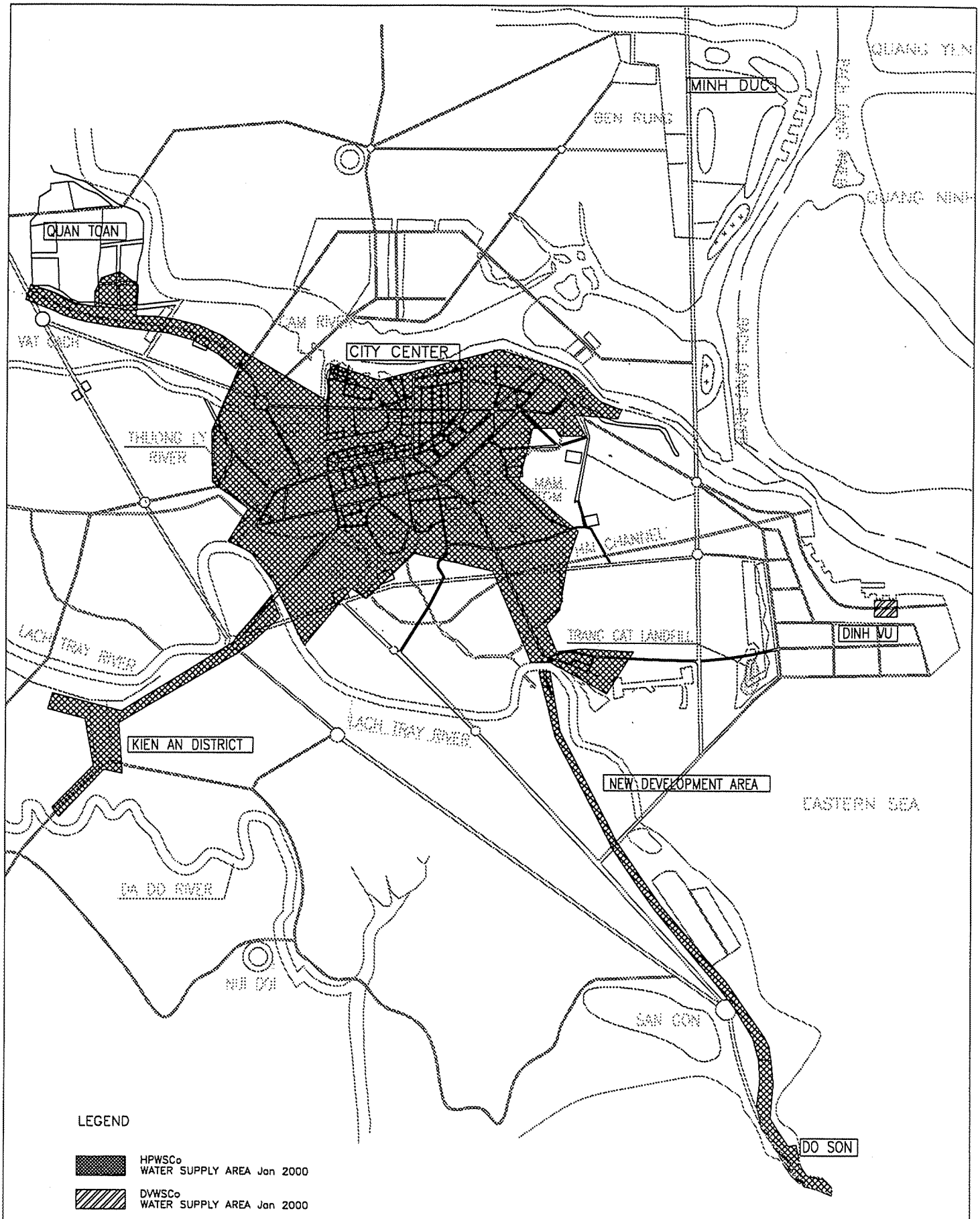
Cost Component	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Construction Cost (1000 US$)
Water Supply											
B. Land Acquisition & Compensation											
1) Hong Bang, Le Chan & Ngo Quyen areas		200	100	62							362
2) Quan Toan area			16								16
3) Kein An area		100	64								164
4) Minh Duc area											0
5) Dinh Vu area											0
6) New Development area			38	20							58
7) Do Son area			20	20							40
Sub-Total	0	300	238	102	0	0	0	0	0	0	640

Cost Component	2011	2012	2013	2014	2015	2016	2017	2018	2019	20120	Construction Cost (1000 US$)
Water Supply											
B. Land Acquisition & Compensation											
1) Hong Bang, Le Chan & Ngo Quyen areas		150	120								270
2) Quan Toan area		40									40
3) Kein An area			30								30
4) Minh Duc area	50	20									70
5) Dinh Vu area											0
6) New Development area		15									15
7) Do Son area		20	20								40
Sub-Total	50	245	170	0	0	0	0	0	0	0	465
Total											1105

Table 2.5.2 Annual Disburcement of Construction and Operation Costs for Water Supply (4/4)

Cost Component	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Construction Cost (1000 US$)
Water Supply											
C. Operation & Maintenance											
1) Hong Bang, Le Chan & Ngo Quyen areas			65	65	65	65	90	90	90	90	620
2) Quan Toan area											0
3) Kein An area							20	20	20	20	80
4) Minh Duc area											0
5) Dinh Vu area											0
6) New Development area							20	20	20	20	80
7) Do Son area							33	33	33	33	132
Sub-Total	0	0	65	65	65	65	163	163	163	163	912

Cost Component	2011	2012	2013	2014	2015	2016	2017	2018	2019	20120	Construction Cost (1000 US$)
Water Supply											
C. Operation & Maintenance											
1) Hong Bang, Le Chan & Ngo Quyen areas	90	90	90	90	90	135	135	135	135	135	1125
2) Quan Toan area											0
3) Kein An area	20	20	20	20	20	20	20	20	20	20	200
4) Minh Duc area						35	35	35	35	35	175
5) Dinh Vu area											0
6) New Development area	20	20	20	20	20	34	34	34	34	34	270
7) Do Son area	33	33	33	33	33	50	50	50	50	50	415
Sub-Total	163	163	163	163	163	274	274	274	274	274	2185
Total											3097



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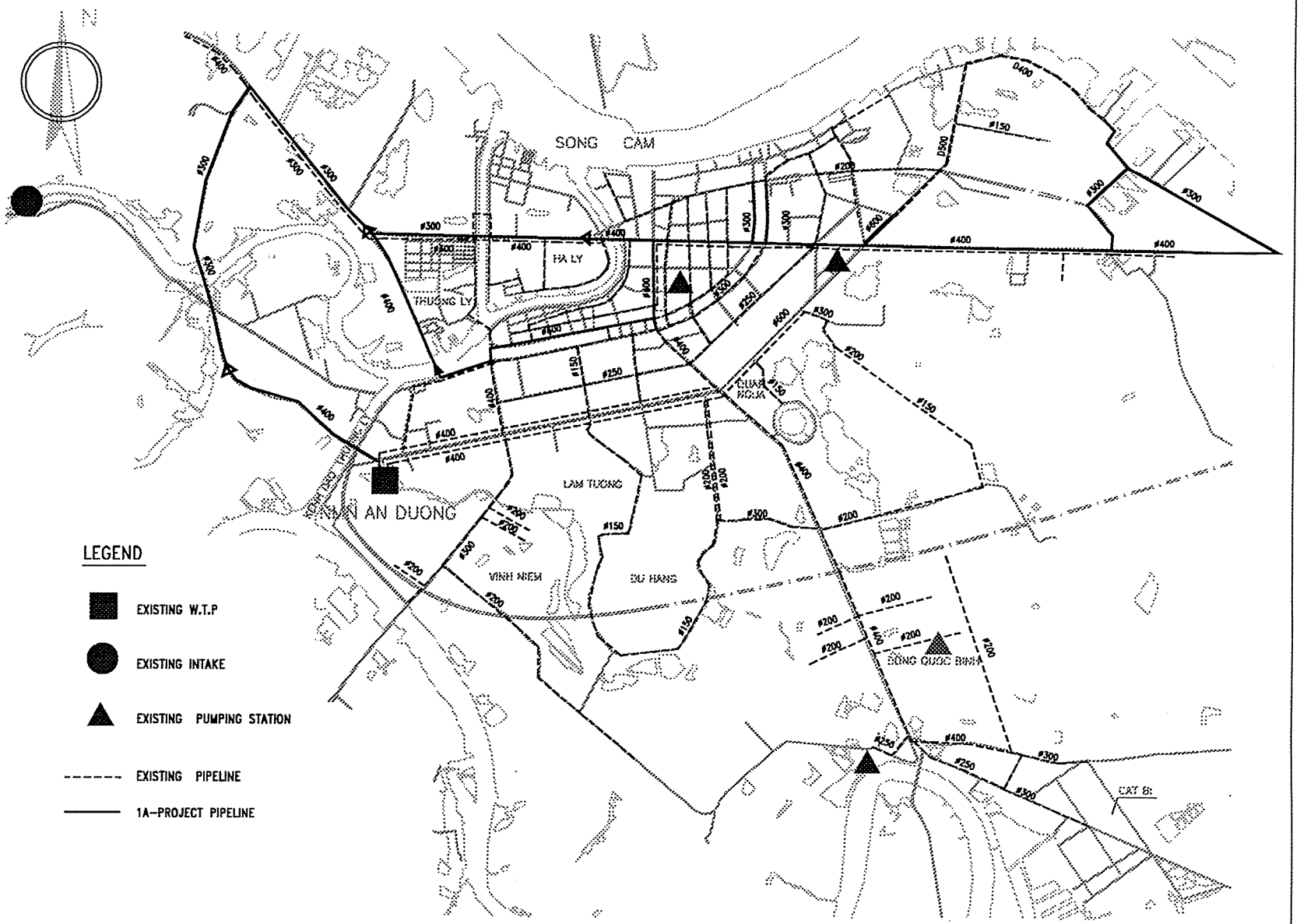
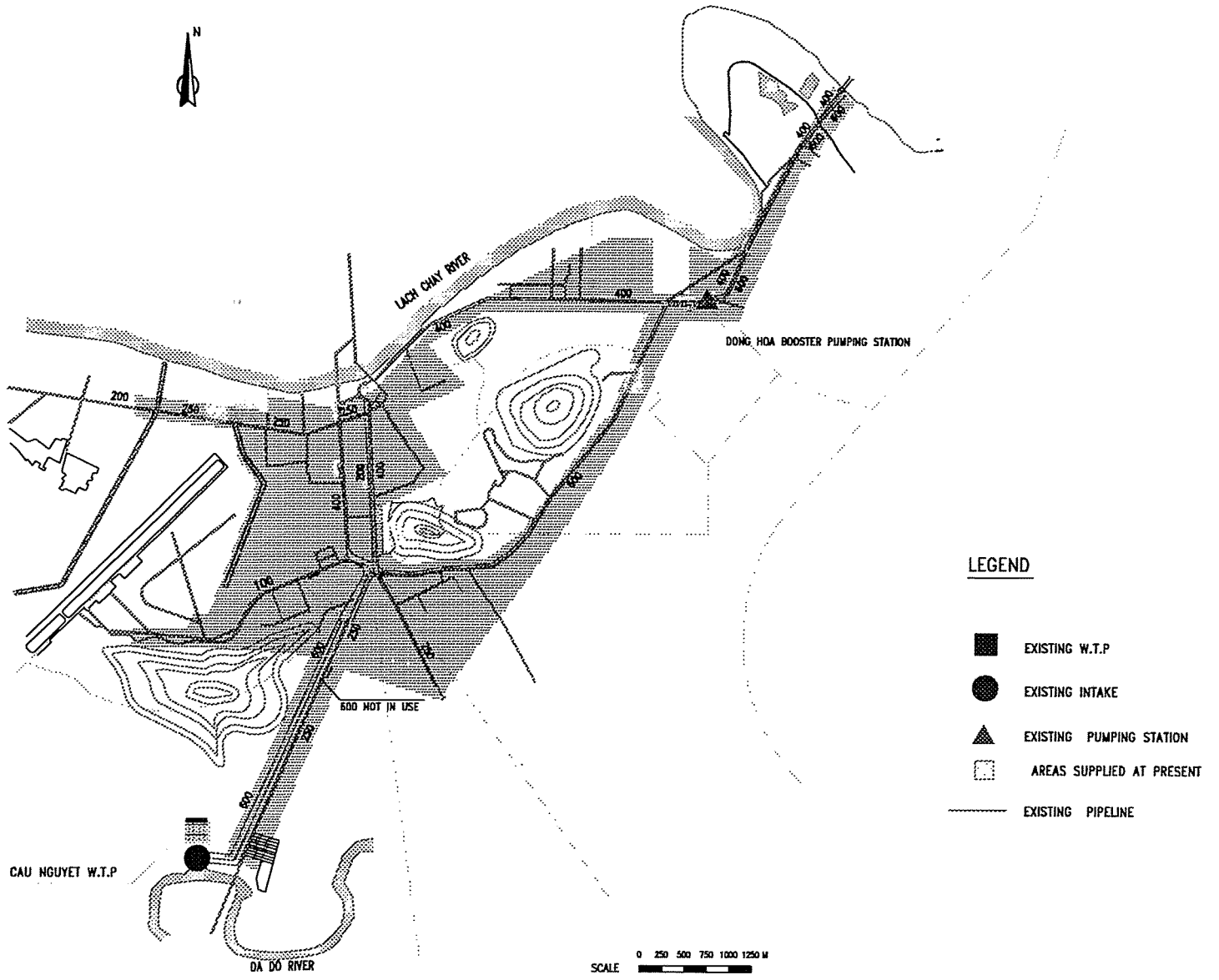
Japan International Cooperation Agency

Figure 2.1.1

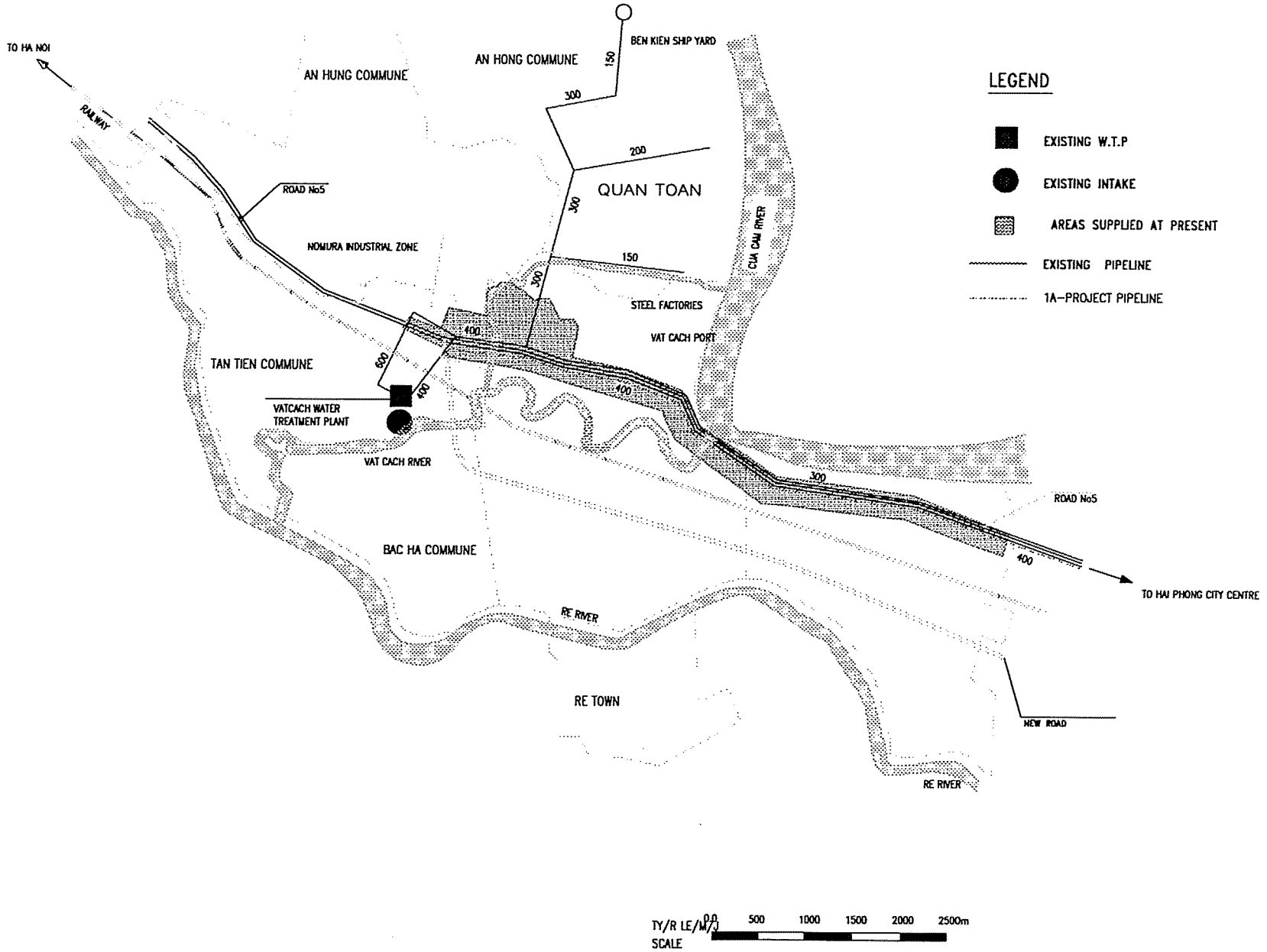
Current Water Supply Area



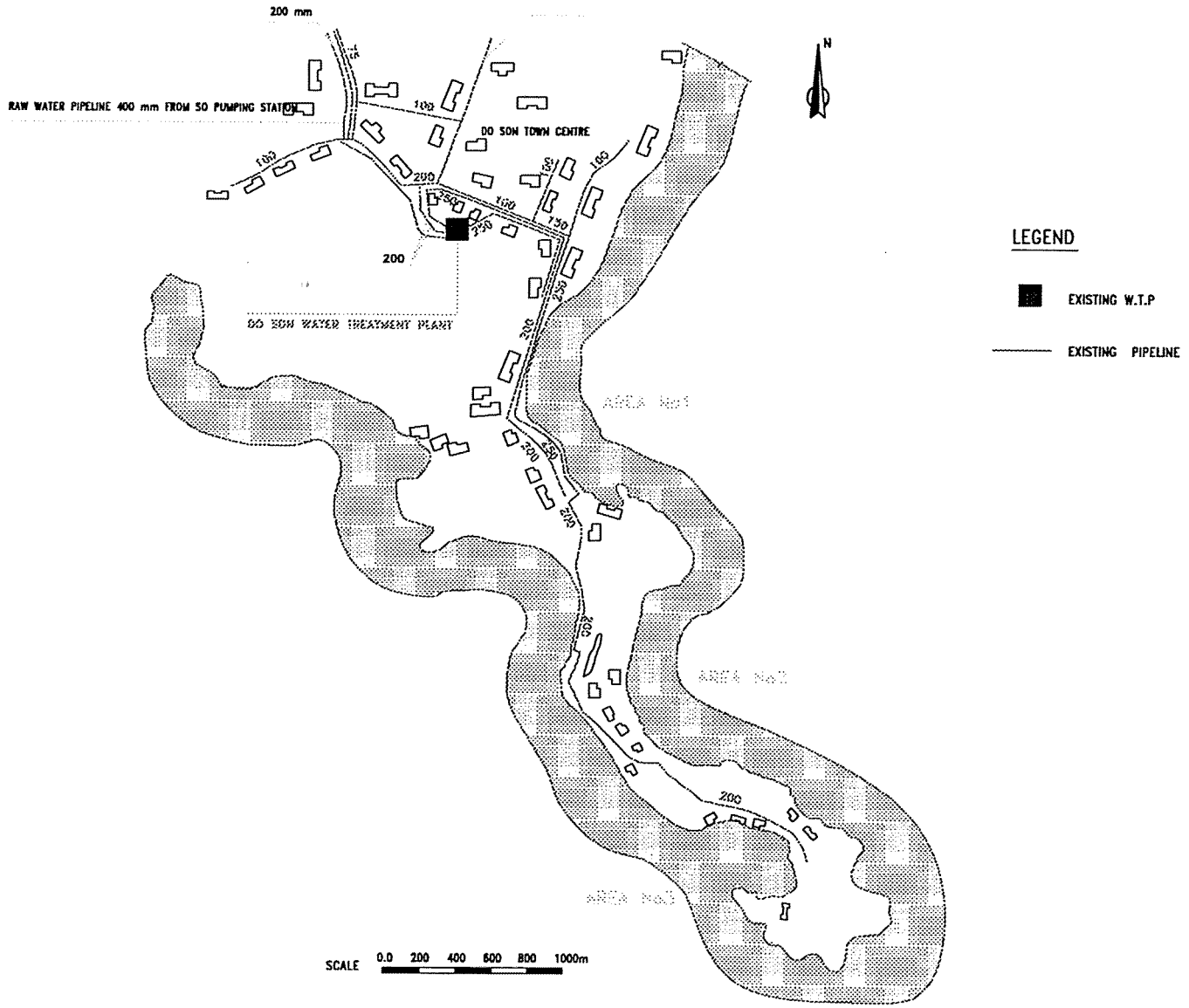
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.1.2 Current Water Supply Network in City Centre
Japan International Cooperation Agency	



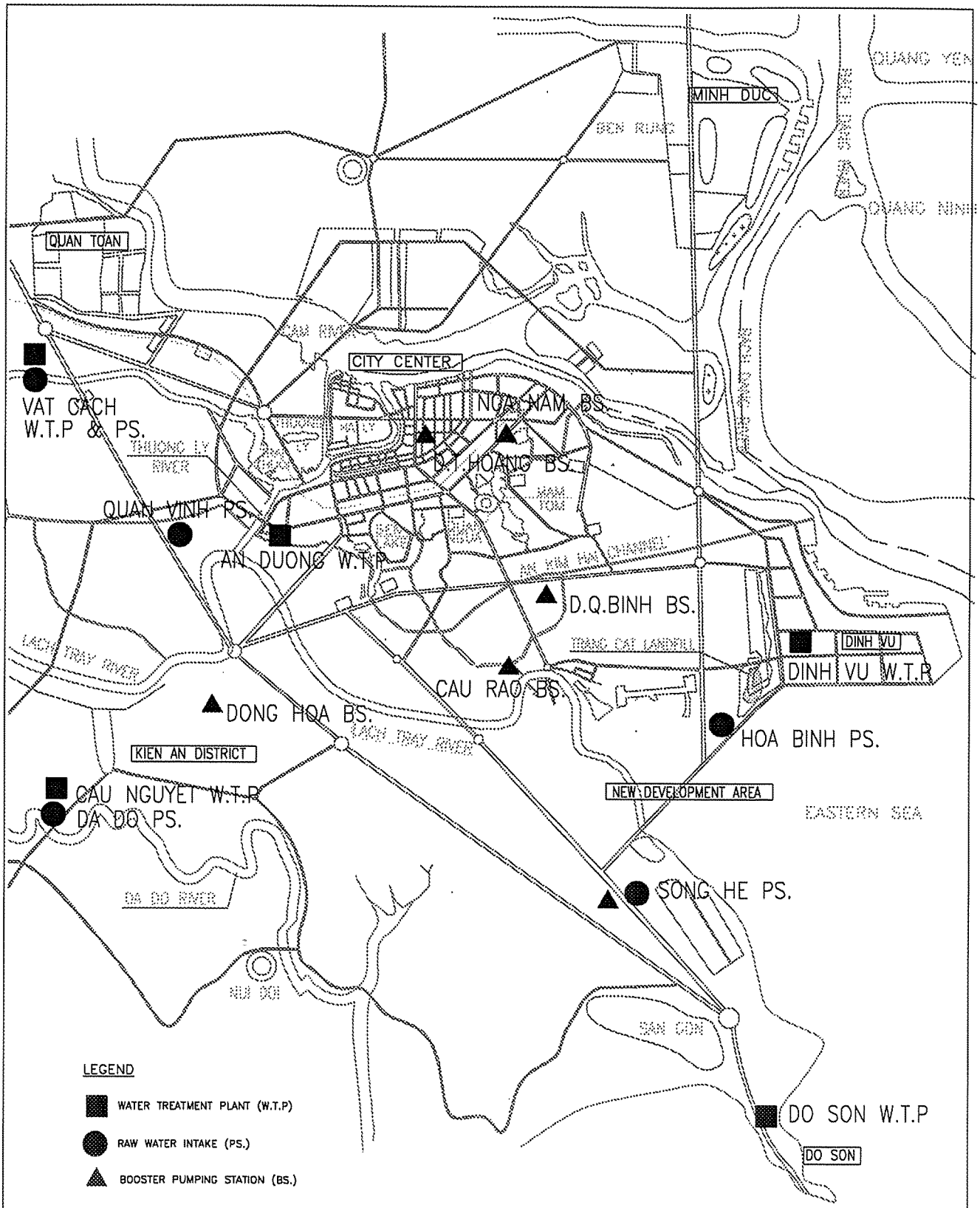
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.1.3 Current Water Supply Network in Kien An
Japan International Cooperation Agency	



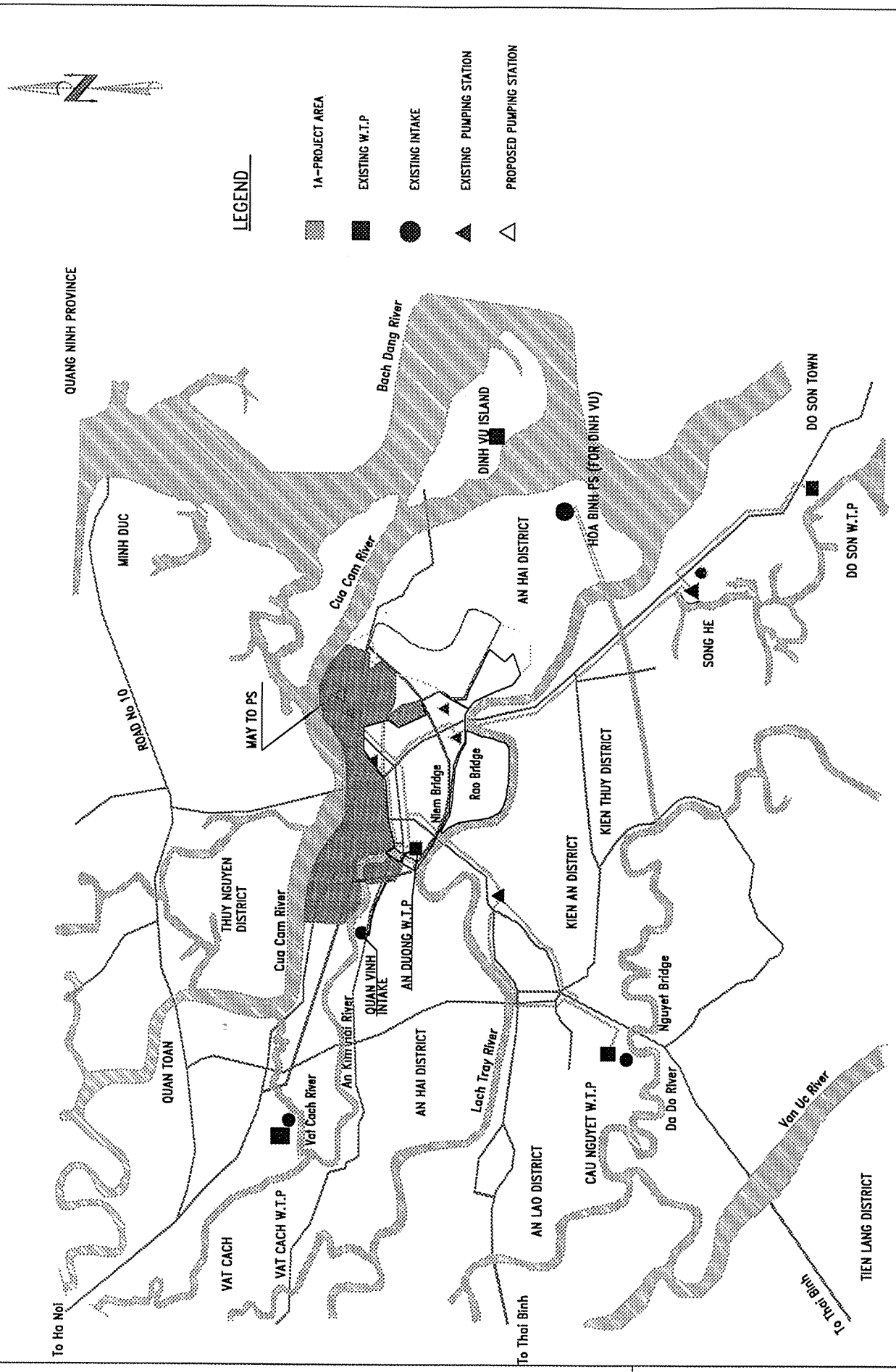
The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.1.4 Current Water Supply Network in Vat Cach-Quan Toan
Japan International Cooperation Agency	



The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.1.5 Current Water Supply Network in Do Son
Japan International Cooperation Agency	



The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.1.6 Location Map of Existing Intakes, Treatment Plants and Booster PS
Japan International Cooperation Agency	



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Japan International Cooperation Agency

Figure 2.4.1

1A-Water Supply Project Area

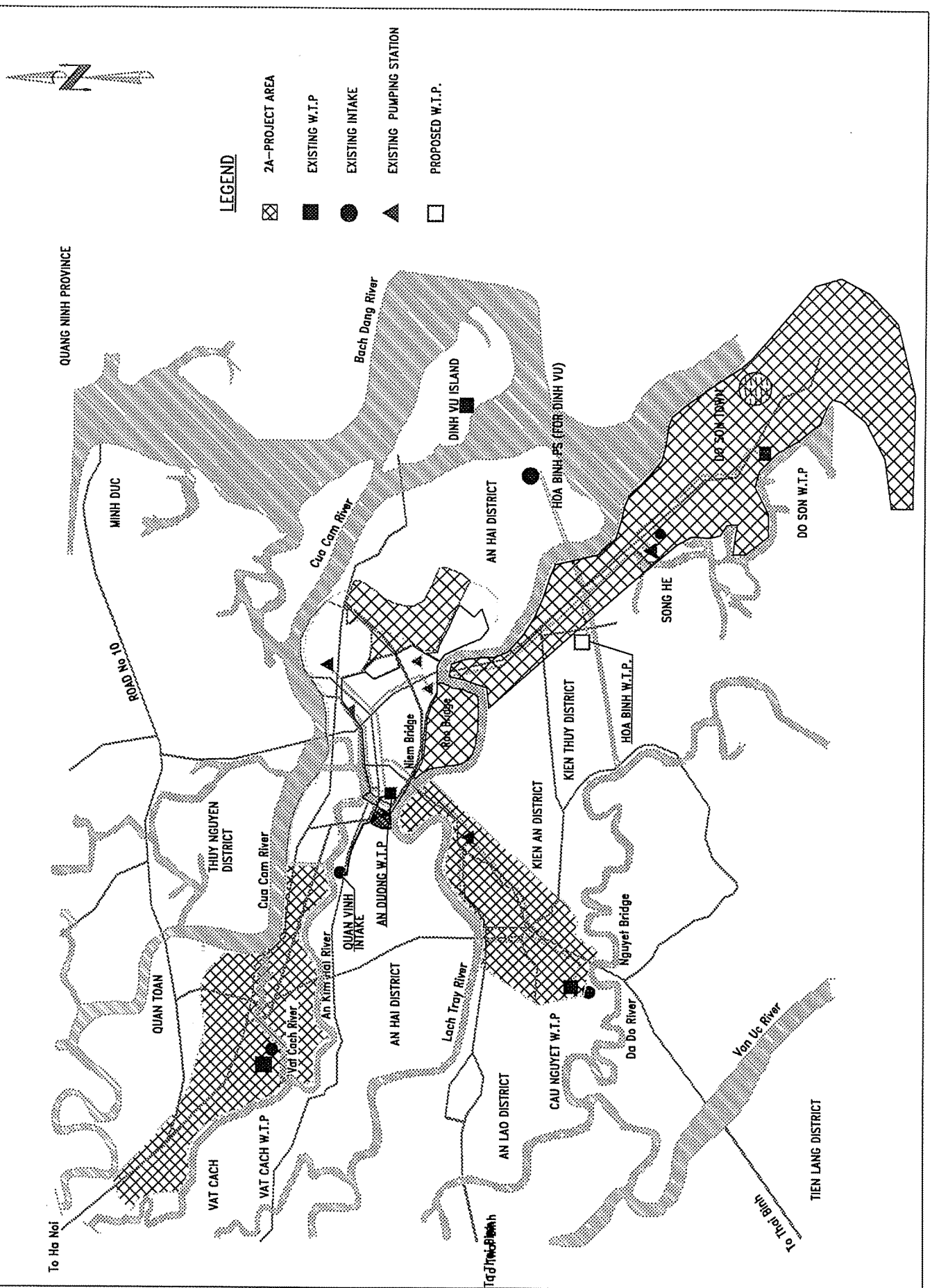

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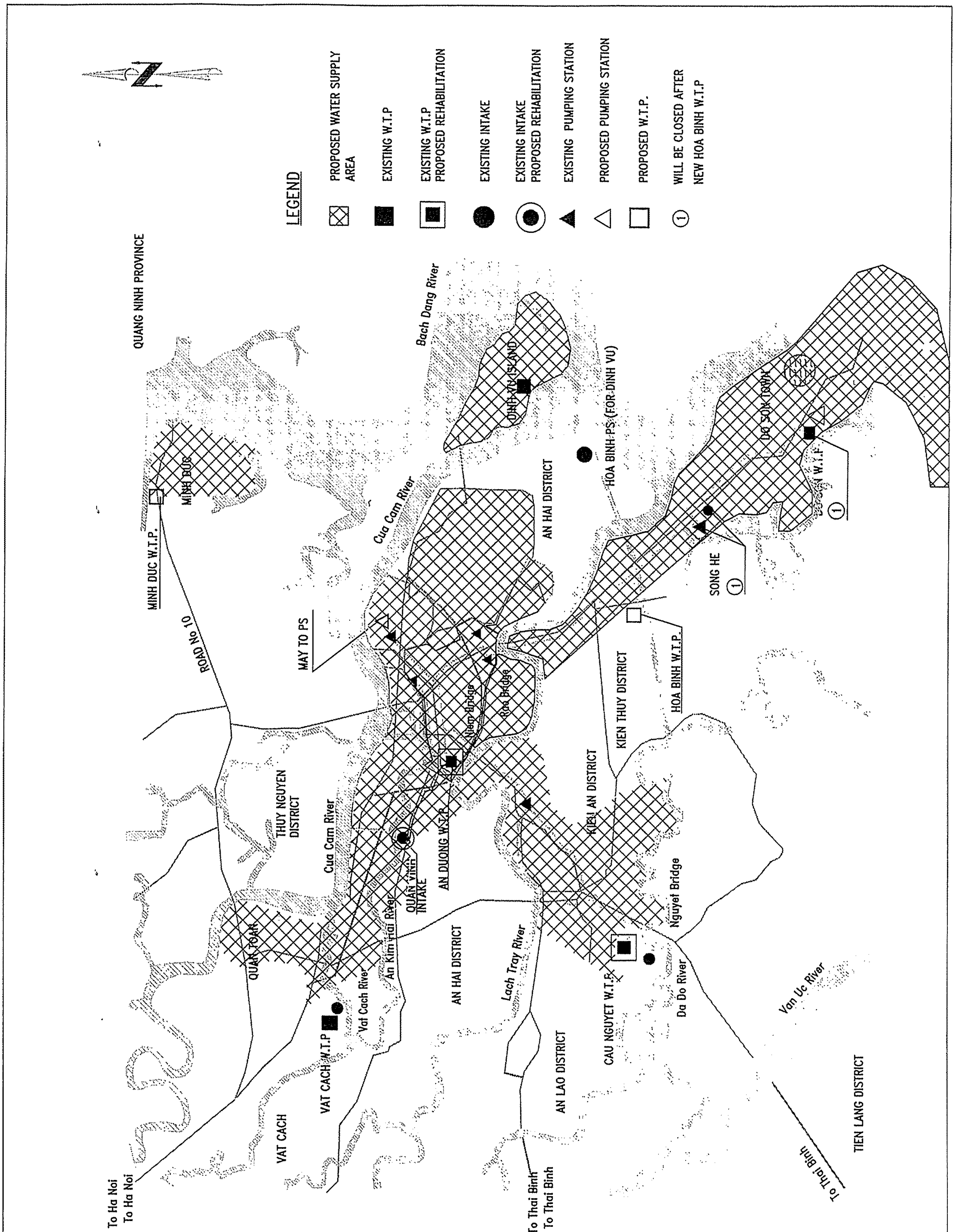
Figure 2.4.2

2A-Water Supply Project Area



The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 2.5.1
Japan International Cooperation Agency	Proposed Water Supply Area

CHAPTER 3 IMPROVEMENT PLAN FOR STORM WATER DRAINAGE

3.1 Current Flooding Conditions

(1) Area Wise Description

Current flooding conditions are described in the following for different areas within the Study Area. As explained and shown in Section 1.4.3, the entire study area is divided into three zones, namely, A, B, and C, based on present and future development. Zone A is the area which is already developed, Zone B is the area where rapid development is going on and Zone C is the area where future growth is expected. As a result, detail planning is to be done for Zone A and B while outline planning is sufficient for Zone C. Planning for Zone A would lead to a priority project to be implemented urgently.

(2) Classification for Drainage and Sewerage

Since drainage and sewerage development plans are synchronized with the anticipated population density, economic growth expected and potential urbanization, suburban areas of Zone A does not require urgent planning due to its low anticipated population density. As a result, new classification is introduced, namely, Class A, B and C.

Class A area include Old City Center within Hong Bang District, Le Chan District, areas south of Le Chan District (2 communes), Ngo Quyen District, and areas west of Ngo Quyen District (4 communes). These areas are characterized as urbanized areas with high population densities. The present and future population densities of the western half of Hong Bang district are quite low compared to the Old City Center of the district. Hence this part is excluded from Class A, though this area would be included within total master plan area. The six non-urban communes are included in the Class A area because of their high present population density and strong possibility of their inclusion in the urban district in near future. The Class A area is shown in Figure 3.1.1.

3.1.1 Class A Areas

For Class A area, the main problems with storm water drainage are as follows:

- Existing drainage (combined) sewers are old and were constructed before urbanization. Consequently, sewers are in poor condition and have inadequate hydraulic capacity
- Variable tide levels at the discharge points restrict free discharge of combined sewers. Consequently, tidal gates, storage lakes, and pumping stations are needed to prevent flooding during high tide

- Ineffective emptying of septic tanks results in large accumulations of septage sludge in sewers, which reduces hydraulic capacity

Flooding occurs regularly in the three urban districts of Class A area. According to SADCO the following flood records represent the worst flooding situation, meaning intense rainfall (rainfall > 100 mm) during high tide for the three urban districts. For the same rainfall occurring at low tide, the flood time is estimated to be shorter. Flood depth is estimated as the difference between the road center line and the flood water level.

Flooding in Le Chan District

Flooding in Residential Areas		
Area	**Flood depth (cm)**	**Flooding time (hours)**
Dong Xuan lowland area	20-30	24-48
Hang Kenh Church area	10-20	2-3
Lam Tuong collective quarter	20-30	12
Lu Hong area	10-15	2-3
An Duong collective quarter	20-30	2-3
Area of lane 380	20-30	2-3
Haiphong Radio and Television comm.	20-30	2-3
Flooding on the Streets		
Street	**Flood depth (cm)**	**Flooding time (hours)**
Pan of Tran Nguyen Han	10-20	2-3
Thien Loi	20-30	1-2
Hang Kenh	10-25	6
Pan of Hai Ba Trung	30-40	12-18
Cat Cut	30-40	12-18

Flooding in Hong Bang District

Flooding in Residential Areas		
Area	**Flood depth (cm)**	**Flooding time (hours)**
Trai Chuoi	10-20	4-5
Part of Thuong Ly phuong	30-40	5-6
Ha Ly phuong	40-50	24-25
	70-80	48-51
Flooding on the Streets		
Street	**Flood depth (cm)**	**Flooding time (hours)**
Minh Khai	30-40	6-8
Le Dai Hanh	30-40	6-8
Ky Dong	30-40	6-8
Phan Chu Trinh	30-40	6-8
Part of Dinh Tien Hoang	30-40	6-8
Trang Trinh	15-20	5-6
Hoang Ngan	15-20	5-6
Ton That Thuyet	15-20	5-6
Pham Hong Thai	15-20	5-6
Nguyen Thai Hoc	15-20	5-6

Flooding in Ngo Quyen District

Flooding on the Streets in surrounding areas		
Street or area	**Flood depth (cm)**	**Flooding time (hours)**
Luong Khanh Thien	30-40	18-24
Tran Khanh Du	30-40	12
May To	30-40	12-15
Vo Thi Sau	30	8-10
Da Nang	30-40	8-10
Nguyen Trai	40-50	18-24
Le Lai	40-50	15-18
Cau Dat	20-30	4-6
Pan of Lach Tray	10-20	3-4
Dong Quoc Binh	15-25	4-5
Cat Bi	30-35	12-15
278 lane	20	6
Cam lane	10-15	3

Present Degree of Flooding Assessed by SADCO

Approximate Frequency	**Rainfall**	**Maximum Rainfall Intensity**	**Tide Conditions**	**% of Total Area**
2 year ARI	60-65 mm	30-40 mm/hr	Low tide	30% of street areas
	65-80 mm	30-40 mm/hr	Rising/Falling	39% of street areas
	60-80 mm	30-40 mm/hr	Low tide	13% of alley areas
	60-80 mm	30-40 mm/hr	Rising/Falling	15% of alley areas
5 year ARI	180-190 mm	40-60 mm/hr	Low tide	49% of street areas
	120-150 mm	40-60 mm/hr	Rising/Falling	63% of street areas
	180 mm	40-50 mm/hr	Low tide	46% of alley areas
	130-150 mm	40-60 mm/hr	High tide	56% of alley areas

For storms with a frequency of 2 year ARI (Average Recurrence Interval), the flooding magnitudes in the street and alley areas was reported as 20-40 cm with a 4-6 hour duration. For storms with a frequency of 5 year ARI, the flooding magnitudes in the street and alley areas was reported as 30-50 cm with 1-3 hour duration.

The following table includes flood data which was collected from the Haiphong Sewerage and Drainage Master Plan.

Rainfall Amount for 3 Storms and Flood Depths in 3 Urban Districts in 1997

		26/6/1997 Rain 155 mm	**21-22/7/1997 Rain 63-53 mm**	**23/8/1997 Rain 108 mm**
Street	**Street Length (m)**	**Flood Depth (cm)**	**Flood Depth (cm)**	**Flood Depth (cm)**
Tran Khanh Du	500	50 - 60	30 - 40	50 - 60
Vo Thi Sau	500	50 - 60	30 - 40	50 - 60
May To	500	50 - 60	30 - 40	50 - 60
Le Lai	1,250	50 - 60	30 - 40	50 - 60
Luong Khanh Thien	1,250	50 - 60	30 - 40	50 - 60
Tran Binh Trong	250	30 - 40	25 - 30	30 - 40
Cau Dat	500	50 - 60	30 - 40	50 - 60
Le Loi	1,500	15 - 20	---	15 - 20
Lam Tuong	250	50 - 60	30 - 40	50
Le Dai Hanh	500	20 - 35	15 - 25	20 - 30
Minh Kai	500	20 - 35	15 - 25	20 - 30
Ly Tu Trong	500	20 - 35	15 - 25	20 - 30
Dinh Dong	500	20 - 30	15 - 20	25 - 30
Lach Tray	1,000	20 - 30	15 - 20	25 - 30

Figure 3.1.2 presents the main flood areas in the three urban districts as reported by SADCO. Figure 3.1.3 presents the main flood areas in the three urban districts as reported in the Haiphong Sewerage and Drainage Master Plan.

Urbanization is expected to continue further in these areas, especially in Le Chan District and Ngo Quyen District, and this will increase the amount of storm water runoff. Storm water drainage in these districts is based on storage lakes, channels, and tidal gates. Flooding will become a bigger problem without improvement and upgrading of the storm water drainage system.

These areas contain the highest population and the main commercial and public activities in the Study Area. Reduction of flooding in these flood areas will have positive socio-economic impacts of meaningful magnitude.

3.1.2 Class B Areas

Class B area include Kien An District, Do Son Town, and Quan Toan Area. These areas are characterized as areas under urbanization with middle population density and tourism areas.

For Class B area the main problems with storm water drainage are as follows:

- Existing drainage (combined) sewers are relatively new, but have been poorly designed and maintained. Condition of the sewers are deteriorating rapidly. Limited funding has resulted in construction of sewers which are small and have inadequate hydraulic capacity
- Variable tide levels at the discharge points restrict free discharge of combined sewers. Consequently, tidal gates, storage lakes, and pumping stations are needed to prevent flooding during high tide

In Class B area flooding occurs regularly in areas where commercial activities are predominant. In these areas the degree of urbanization is higher than in other areas, which are mostly suburban and residential. Because of these localized urbanized conditions, storm water runoff is high, which causes flooding, but the flooding magnitude is not great.

Reduction of flooding in the main commercial areas will have positive socio-economic impacts, but the magnitude of the impacts will not be great. Urbanization of the suburban residential areas will occur, but not at a great rate.

3.1.3 Class C Areas

Class C area include Minh Duc, New Development Area, and Dinh Vu. These areas are characterized as rural or undeveloped areas with low population density where agricultural land use is dominating.

Drainage systems in Minh Duc and the New Development Area have not been constructed, because these areas are not yet developed to an extent where flooding occurs because of storm water runoff.

Urbanization of Minh Duc and New Development Areas is not expected in the near future, and there is no immediate need for drainage improvements in the city.

In Dinh Vu, the drainage system is the responsibility of the Economic Zone and the industries which locate in the area.

3.2 Outline of Proposed World Bank Sanitation Project and FINNIDA Projects

3.2.1 Summary of Projects

(1) World Bank Sanitation Project

The proposed World Bank Sanitation Project consists of the following system and facility measures for storm water drainage improvements:

- Cleaning, inspection and rehabilitation of existing main, secondary and tertiary combined sewer network in Class A area: Old City Center and Northeast (NE) and Southwest (SW) Channel systems. The cleaning and inspection will cover the existing main combined sewer network (170 km). The inspection and assessment will be done by use of CCTV (closed circuit television)
- Rehabilitation will include about 70 km of existing pipes and box sewers at the main, branch and tertiary level. Rehabilitation will comprise repair or replacement of the pipes, sealing of leaks, repairs to manholes and sewer outlets, and repair and construction of gully pots
- Figure 3.2.1 shows the areas of sewer cleaning, inspection and rehabilitation
- Construction of new main combined sewers in Class A area: Old City Center and NE Channel system. These new sewers (7.6 km) will be constructed to provide additional hydraulic capacity to reduce flooding in prioritized flood areas in the old city center of Haiphong
- Figure 3.2.2 shows the location of these new main combined sewers
- Rehabilitation of two drainage channel systems in Class A area: Northeast and Southwest Channel systems. Rehabilitation of the drainage channel systems (total length: 6 km) will be done to provide additional hydraulic capacity and maintenance access. Proposed rehabilitation works include dredging, side-slope lining, and construction of a maintenance road on one side of the channel

Figure 3.2.3 shows the location of these 2 drainage channel systems:

- Rehabilitation of four lakes in Class A area: Northeast and Southwest Drainage Basins (Tien Nga Lake, Sen Lake, Lam Tuong Lake, and Du Hang Lake). Rehabilitation of the lakes (total surface area: 10.9 ha) will be done to improve flow and storage capacities as well as to provide an access road for lake

maintenance. Proposed rehabilitation works include dredging, side-slope lining, and construction of maintenance road around the lake

- Figure 3.2.3 shows the location of these four lakes
- Rehabilitation of three tidal gates in Class A area: Le Chan District and Ngo Quyen District. Rehabilitation of May Den tidal gate, Vinh Niem tidal gate, and Cat Bi tidal gate will involve structural rehabilitation as well as replacement of the present manual drives with electrically operated, manually controlled drives

Figure 3.2.3 shows the location of these three tidal gates.

(2) FINNIDA Projects

Proposed FINNIDA projects consist of the following system and facility measures for storm water drainage improvements:

- Construction of two storm water pumping stations in Class A area: Northeast and Southwest Channel systems. Storm water pumping stations are to be used to pump storm water from the Northeast and Southwest drainage systems during high tide when the tidal gates are closed. Pumping stations are located at May Den tidal gate and Vinh Niem tidal gate. The total capacity of each pumping station is 9 m^3/s

  Figure 3.2.4 shows the location of these two pumping stations.

3.2.2 Planning Criteria

(1) World Bank Sanitation Project

Design of new main sewers was based on the following criteria:

- Storm with a frequency of 2 year ARI
- Rational method with a time of concentration of 15 minutes for narrow catchment areas and not more than 30 minutes for wide catchment areas
- A runoff coefficient equal to 0.7 was used for urban conditions
- For sewers draining to the Cam River the design downstream water level was +2.5 m (the north Vietnam Datum). This design criteria provides a 65 % chance that no flooding would occur for a design storm of one hour duration
- For sewers draining to the Northeast Channel the design downstream water level was +2.2 m
- Rehabilitation of drainage channels is based on the following criteria
- Storm with 10 year ARI during falling tide level conditions
- For the Northeast Channel the design flowrate distribution in the channel corresponds to the maximum discharge flowrate of 28.9 m^3/s and a water level of +2.2 m at the May Den tidal gate

- For the Southwest Channel the design flowrate distribution in the channel corresponds to the maximum discharge flowrate of 26.2 m^3/s and a water level of +2.2 m at the May Den tidal gate
- Catchment area of Northeast Drainage Basin: 650 ha
- Catchment area of Southwest Drainage Basin: 450 ha
- Levels of roads along channels and around lakes: +3.2 m
- Levels of channel and lake bottoms: +0.5 m
- Side-slopes of channels and lakes: 1:1.5
- Minimum water level in lakes: +1.5 m
- Maximum water level in lakes: +2.9 m (except Sen Lake)
- Maximum water level in lakes: +3.2 m (Sen Lake)

(2) FINNIDA Storm Water Pumping Stations Project

Computer simulations were done to determine the design capacity of the pumping stations and to assess the amount of flooding with and without the Project.

Based on review of flood data and computer simulations, 10 flood affected areas were identified for both the Northeast and Southwest Drainage Basins. The computer simulations only considered storms with average recurrence intervals of 2 years, 5 years, 10 years and 20 years. Flooding from storms with average recurrence intervals of 1 year or less are generally more associated with ward areas, which are not directly associated with flooding of the main sewers. Flooding from storms of 2 Year ARI and more were then assessed and extrapolated to provide assessments for storms of 1 Year ARI and less.

The flood assessments are based on the percentage of area within a flood affected area experiencing flooding which causes flood damages and other economic costs for a storm with an average recurrence interval. Flood assessments are done for two alternatives, with and without the Project. Flood reductions are determined on the percentage of areas within a flood affected area which experiences flooding without the Project, but which does not experience flooding with the Project.

The yearly reduction in flooding in the Northeast Drainage Basin, during a 20 year period, which includes the risk factors for storms with different average recurrence intervals and high tide conditions, is from 29.9 ha to 3.5 ha, or an 88 % reduction. For the Southwest Drainage Basin, the flood area reduction is from 36.7 ha to 10.2 ha, or a 72 % reduction.

3.2.3 Implementation Schedule and Estimated Cost

(1) World Bank Sanitation Project

The direct costs of the project was estimated as US$30.644 million. The total costs include grants from FINNIDA of US$6.993 million which will cover technical assistance and construction management services.

The World Bank Project includes four contracts:

- Contract HPSANP-C2 is for procurement of vehicles and equipment. Bids are to be received in August 2000. Delivery is estimated to occur during the 1st and 2nd Quarters in the Year 2001
- Contract HPSANP-C1A is for cleaning and inspection of sewers. It is estimated that work would begin in the 3rd Quarter of the Year 2001 and would finish during the 1st Quarter of the Year 2003
- Contract HPSANP-C1B is for rehabilitation of sewers. Work would begin after Contract HPSANP-C1A is completed and is estimated to begin in the 3rd Quarter of the Year 2003. The work is estimated to finish during the 4th Quarter of the Year 2004
- Contract HPSANP-C1C is for civil works (new sewers, channel and lake rehabilitation, sludge treatment facilities, and other works). It is estimated that work would begin in the 1st Quarter of the Year 2001 and would finish during the 4th Quarter of the Year 2003

It is then estimated that the project would then be completed by the 4th Quarter of the Year 2004.

(2) FINNIDA Storm Water Pumping Station Project

The direct cost of the project was estimated as US$2.154 million.

Approval of the Feasibility Study by local and governmental organizations is the first requirement for the Project. It was estimated that six months are needed to get the necessary approvals after application of the project and submission of the Feasibility Study.

Bidding to select the supplier would then be based on the preliminary designs in the Feasibility Study. After the supplier has been selected, the credit application for concessional credit would then be needed. It was estimated that six months are needed to get the necessary approvals.

After the concessional credit application would be accepted, then it is estimated that six months is needed to prepare the detailed designs and to obtain the approvals from local and governmental organizations in Vietnam. After the approvals have

been obtained, construction of the pumping stations would begin and is estimated to last not more than nine months.

Finally, it was set that construction would begin during the 1st Quarter of the Year 2002 and be finished by the end of the Year 2003.

3.2.4 Organizational Recommendations

(1) World Bank Sanitation Project

The objective of the Project for improved quality of environment and sanitation is supported by a set of related measures meant to enhance SADCO towards a self sustaining institution, precisely, a State-owned Enterprise, as follows:

- To support Haiphong City and the HPPC in their effort to further realign roles of the public utilities and enterprises within its domain. Specifically at SADCO, to initiate a dialogue for more focussed operation versus the associated utilities
- To strengthen the managerial capacity and administrative ability and to develop the organization
- To strengthen financial management and control at SADCO and to support financial transparency
- To establish a community oriented approach by giving due consideration to the requirements of the customers and to induce the need among the community members to improve sanitation and within the process to develop corresponding services to satisfy their needs
- To develop standard operations, job descriptions and performance indicators as well as monitoring systems and reporting practices for SADCO in transition and to meet the challenges of the emerging market economy
- To divest from regulatory functions (to be relocated) and to develop contractual capacity
- To support environmental objectives
- To develop human resources at all levels of the organization, including technical and administrative skills
- To encourage innovation in management and in the customer approach as well as in the scope of the services to be provided

The technical assistance component of the project, which is funded by FINNIDA, includes the following functional areas:

- Improving operational capacity of SADCO through training and institution building to develop Project's sustainability, to assist SADCO to carry out its principal function

- Proposed Community Mobilization Programme in cooperation with an NGO and including a Revolving Fund
- Studies to highlight key problems, and to propose systems and new procedures for implementation
- Technical assistance to support implementation of the proposed systems and if required, longer term support to the management of SADCO
- Pilot-scale investments in exceptional cases, through procurement of specialized operation and maintenance equipment, or following a distinct scope of a separate project document

(2) FINNIDA Storm Water Pumping Station Project

The Haiphong Water Supply and Sanitation Programme had a specific programme at SADCO for upgrading of the tidal gates by the end of 2000, including training to be given to the operators. Issues related to the behaviour of the hydraulic system were included.

During implementation of the Project, specific training would be provided by the equipment supplier with the cost of training included in the Project costs.

3.3 Hydrological and Hydrographic Criteria for Drainage Improvement

3.3.1 Hydrological Criteria

The climate in the Haiphong area is dominated by the monsoons, like the climate of the whole of Southeast Asia. Cold and dry northeastern winds blow over the northeastern parts of South-Asia and bring rather cold air to northern Vietnam, making the temperature even to +6 to +8^{o}C. In February and March the high pressure through Asia weakens gradually and the velocity of the northeastern winds decreases. When the process continues, a transition to the southern monsoon begins and precipitation increases rapidly. The transition period in Haiphong occurs in April and May. The rainy season lasts until November, the rainiest months are July and August.

The precipitation in December and January is usually low. In December to February the mean daily temperature is +17 to +18^{o}C. July is the warmest month with a mean temperature of +28.2^{o}C. The seasonal variation in temperature is over +11^{o}C. The absolute minimum and maximum temperatures are +4.5^{o}C and +37.8^{o}C, respectively

The mean annual precipitation during 1958-1977 was 1754 mm at the Phu Lien observatory in Kien An, southwest of Haiphong. The total precipitation from May to September was 1357 mm, which is 77 % of the annual value. The maximum monthly precipitation is 321 mm, occurring in August. The mean monthly

precipitation is lowest from December to February averaging about 25 mm. The following tables present monthly precipitation data.

Monthly Precipitation at Phu Lien Observatory in 1971 - 1990

Month	Mean monthly mm	Minimum total mm	Maximum total mm	Maximum daily mm
January	24	0	126	59
February	26	1	135	33
March	51	8	134	43
April	79	3	282	78
May	214	38	660	224
June	240	78	594	133
July	279	96	567	173
August	321	115	903	362
September	303	30	1193	264
October	145	5	610	177
November	52	0	150	58
December	24	0	109	52

Precipitation in 1991 - 1994

Month	1991 Rainfall mm	1992 Rainfall mm	1993 Rainfall mm	1994 Rainfall mm
January	7.3	111.4	15.6	25.6
February	5.4	40.8	20.2	34.9
March	66.4	47.5	22.9	49.0
April	11.2	34.4	29.3	86.9
May	108.8	137.2	222.9	198.2
June	161.7	447.6	113.7	242.8
July	154.9	514.9	61.7	264.5
August	151.8	180.6	488.7	341.5
September	64.1	293.1	287.5	280.8
October	18.9	72.0	6.0	158.5
November	13.9	11.7	113.3	50.5
December	42.1	32.8	36.0	264.0
Total	**806.5**	**1859.2**	**1385.4**	**1997.2**

Rainfall frequency and intensity data are used as planning criteria. The data is based on observations made at Phu Lien Observatory. The data is presented in Figure 3.3.1 and is equivalent to the rainfall data used as planning criteria in the Haiphong Sewerage and Drainage Master Plan.

3.3.2 Hydrographic Criteria

Water amounts in the rivers in the Study Area have seasonal fluctuations depending on runoff in the catchment area. Specific discharge observed at the non-tidal sites of the Thai Binh river system is over 20 l/s/km^2, with maximum exceeding 1,000 l/s/km^2, and minimum varying from 1 to 3 l/s/km^2. Nevertheless, water levels in Haiphong fluctuate only little with variations in discharge. The influence of the tide is much more important. The reason for this phenomenon is the immediate vicinity of the sea.

Consequently, tide is the main cause of variations of water levels in rivers surrounding Haiphong. It affects both hydrology and water quality of the rivers. On the Red River plain, the tide penetrates as far as 180 km into the delta. The maximum tide amplitudes at 3 marine stations are given in the following table.

Maximum Tide Amplitudes (cm) at 3 Marine Stations

	Hon Gai	Hon Dau	Hon Ngu
January	416	375	266
February	378	360	327
March	355	329	217
April	352	318	255
May	378	354	252
June	408	370	274
July	411	372	280
August	384	347	262
September	348	327	235
October	381	363	264
November	405	370	274
December	418	394	328

Tide in the coastal area of Haiphong is a homogenous daily tide. Maximum amplitude observed at Hong Dau island, off Do Son, is +3.94 m. Considerable regular fluctuations occur in tide amplitude. Exceptional weather conditions, such as monsoons, typhoons, whirlwinds, etc. cause complicated variations and sometimes significant deviations from normal fluctuation.

The moment of flow and ebb occurrence varies. In a period of one year, flow and ebb can occur at any time of the day.

Regular fluctuations of the tide are:

- Diurnal tide fluctuation cycle

  Most of the time, about 25 days a month, there are daily flow and ebb. Duration of flow and ebb is about the same, 12 hours 24 minutes. During the low tide period there may be two flows and ebbs a day, but there are, at most, 3 such days in a month.

- Semi-monthly cycle

  High tide period usually occurs 2–3 days after the moon is at the maximal latitude to the north and to the south. Water level fluctuates rapidly (up to 0.5 m in one hour). Low tide period usually occurs 2–3 days after the moon passes equatorial plane. Water level does not fluctuate much, sometimes it seems to be static. In these days there are often two flows and ebbs a day.

- Seasonal cycle

  The tide also has a semi-annual cycle. Maximum flow occurs at the summer solstice (23rd of June) and at the winter solstice (23rd of December), while the extreme ebb occurs at vernal and autumnal equinoxes (21st of March and 21st of September).

- Long term cycle

  Among long term cycles of tide fluctuation only the 9 year and 19 year cycles have considerable influence on tide characteristics.

Hydrographic planning conditions is based on tide level data measured at the Cam River near Haiphong.

Tide level conditions are developed using data for tide levels with a 10 year ARI. The data is presented in Figure 3.3.2. The figure includes the tide levels which also occur during a 16 day period, using January as a reference month.

Based on this data the maximum water level is +4.1 m and the minimum water level is +1.0 m. The complete tide cycle is 24 hours. The duration of water levels above +2.5 m is approximately 12 hours.

3.4 System and Facility Measures for Storm Water Drainage Improvements

3.4.1 Planning Objectives

The planning objectives for storm water drainage are as follows:

- Main objective is to improve and upgrade the storm water drainage system to promote a healthy living environment and favorable urban development
- Improvements in storm water drainage are directed to flood areas where flood reductions have greatest socio-economic impacts
- Selected measures for storm water drainage should be sustainable and compatible with local standards and practices

Flooding problems are associated with the incidence and depth of flooding as well as flood duration. Highest priority is given to areas which experience frequent flooding with deep flood water and long flood durations.

The second highest priority is given to areas which experience deep flood depths that cause physical damage to buildings and infrastructure, even though the flood duration may be short, or to areas which experience flooding of long durations, even if the depth of flooding is moderate.

Third highest priority is given to areas which experience frequent flooding, but the flood depths and durations are moderate.

Flood waters from combined sewer systems also include raw sewage, which is considered a serious public health risk. This situation does not promote a healthy living environment and favorable urban development cannot be achieved.

Socio-economic benefits derived from improvements in storm water drainage for living areas experiencing flooding include the following:

- Risk of faecal contamination of water supply facilities is reduced
- Occurrence of water borne diseases is reduced
- Damage to road infrastructure is reduced
- Disturbance to traffic is reduced
- Property values and property tax levies will increase
- Inconvenience of flooding is reduced
- Attraction for investors will increase

3.4.2 Planning Strategy

Drainage related interventions are required when a certain area is susceptible to frequent flooding. Usually this occurs where the surface runoff is high and natural percolation is low. The governing factors include ratio of paved area, soil property, vegetation, elevation, distance to surface water bodies, elevation of groundwater and climate pattern. Urbanization and population density is the key factor determining appropriate drainage interventions.

The following land use based selection criterion was adopted to select required storm water drainage system in the Study Area.

Parameter Determining Investments in Storm Water Drainage

Ratio of developed area	Range	Target
High	> 0.4	Storm water collection and disposal system
Low	< 0.4	Natural Drainage

In areas where ratio of paved or developed area is high, the drainage system should be developed so that storm water can be collected and disposed. For this purpose some or all of the following components are required; drainage collection pipes, drainage channels, lakes, regulating ponds and pumping stations.

Of the two types of sewerage and drainage collection systems, namely separate and combined systems, the separate system is selected as the preferred collection

system for the Study Area complying with the "Decision by the Prime Minister On the Approval of the Development Orientation to 2020 for Vietnam Municipal Drainage and Sewerage System (Hanoi March 05,1999.)".

However, if development of a separate sewerage system is not realistic from a technical and/or financial point of view, as could be the case for the densely populated area in the 3 urban districts, a combined system may be adopted. In case of low prevailing hydraulic gradient, tidal effect and/or low channel storage capacity, pumping stations are proposed to dispose storm water.

For areas with low ratio of paved area, natural drainage capacity is sufficient to drain the storm water, so no artificial drainage system is proposed. However, for special localized cases like commercial areas, tourist spots, areas with low surface elevation, and areas prone to perpetual flooding, installation of a drainage system can be considered.

3.4.3 Planning Outline

Ratio of developed area of each district is given below.

Ratio of Developed Area of Each District

District	Developed Area (ha)			Total Area (ha)	Ratio of developed area to total area		
	1999	2010	2020		1999	2010	2020
Hong Bang District	964	1043	1183	1520	0.63	0.69	0.78
Le Chan District	424	424	424	440	0.96	0.96	0.96
Ngo Quyen District	971	1029	1095	1220	0.80	0.84	0.90
Kien An District	795	919	1054	2670	0.30	0.34	0.40
Do Son Town	547	686	854	3950	0.14	0.17	0.22
Quan Toan	122	205	300	500	0.24	0.41	0.60
Minh Duc	176	212	312	1502	0.12	0.14	0.21
Dinh Vu	55	151	320	1350	0.04	0.111	0.24
New Development Area	180	265	371	1850	0.10	0.14	0.20

The developed area includes public area, hospitals and schools, residential urban land, residential rural land, tourism facilities, industries and warehouses, traffic land and national defense area. The non-development area includes green area, rice field, aqua-culture, forests and hills, water bodies and others.

Based on the ratio of developed area, appropriate target drainage systems until the Year 2020 are selected as follows.

Appropriate Target Drainage Systems in Study Area

Area	2020
3 Urban Districts	Drainage System
Kien An District	Drainage System
Do Son Town	Natural Drainage
Quan Toan	---
Minh Duc	Natural Drainage
Dinh Vu	---
New Development Area	Natural Drainage

The three Urban Districts and Kien An District are to be served with drainage system, and the rest of the Study Area is to be served by natural drainage.

For areas with industrial zones like Dinh Vu and Quan Toan, drainage will not be the responsibility of the public sector. Economic Zone Authority should take responsibility for the drainage in these arean.

3.4.4 Targets and Principles for Improvement

(1) Phased Implementation

The following schedule is adopted to allow phased implementation of storm water drainage improvements.

- Year 2010: Short-term
- Year 2020: Long- term

(2) Target Drainage Levels

Three different drainage target levels are defined. These levels were based on the frequency of high tide conditions and the frequency of expected storms and rainfall magnitudes.

High tide conditions with a frequency of a 10 year average recurrence interval (ARI) was selected for all three drainage target levels. However, the frequency of the expected storms and rainfall magnitudes were different for each drainage target level and system element and are defined as follows.

- Level A Storm with a frequency of 10 year ARI
- Level B Storm with a frequency of 5 year ARI
- Level C Storm with a frequency of 2 year ARI

(3) Target Areas

1) Class A Areas

The main target drainage areas are in Hong Bang District, Le Chan District and Ngo Quyen District (approximate total area of 21 km^2). Flooding occurs regularly in these areas. These areas also contain the highest population and

the main commercial and public activities in the Study Area. Reduction of flooding in these flood areas will have positive socio-economic impacts of meaningful magnitude.

Considering the population density, administrative importance and economic activity, the urgency to implement drainage facilities for Class A area is much higher than other two areas.

2) Class B Areas

The main commercial areas in Class B area where flooding occurs regularly are the secondary target for drainage improvement. Also, areas of tourism related activities should be covered by the drainage system. Other target areas in Class B area include suburban residential areas where urbanization will occur, and where flooding is expected to be a problem in the future without system improvements.

The urgency of storm water drainage improvements in Class B area is considered as not great. Reduction of flooding in the main commercial areas will have positive socio-economic impacts, but the magnitude of the impacts will not be great. Urbanization of the suburban residential areas will occur, but not at a great rate.

In Quan Toan the drainage system is the responsibility of the Economic Zone and the industries which locate in the area.

3) Class C Areas

Class C area are not considered as targets for providing drainage.

Urbanization of Minh Duc and New Development Area is not expected in the near future, and natural drainage will be sufficient.

In Dinh Vu the drainage system is the responsibility of the Economic Zone and the industries which locate in the area.

3.5 Preliminary Design and Cost Estimates for the Optimum Measures for Class A Area

3.5.1 Alternatives, Timeframes, and Preliminary Costs Estimates

(1) Formulation of Modules

Definition of alternatives for Class A area consists of a number of modules or components. These modules are based on sub-areas within the target area and target drainage levels. These do not consider implementation phasing and implementation cost.

1) Factors to be Considered

(a) Target/objective Area

Selection of the target area for which alternative plans should be identified and the most appropriate one should be selected after comparison for which a feasibility study should be carried out.

(b) Division of the Selected Target Area into Sub-areas Considering

- Current land use and future land use plan, future growth potential
- Current and future planned population density
- Natural conditions related to the drainage, including altitude, number of outlets connected with tidal rivers and channels
- Whether combined sewers exist or not

(c) Target Level of Development

Target drainage levels are defined for different elements of the drainage system. The levels of the different elements of the drainage system are defined as follows:

- Grade A Level Storage lakes, drainage channels, and pumping stations
- Grade B Level Main and branch combined sewers
- Grade C Level Tertiary sewers

(d) Relevance with other Sanitation Improvement/sewerage Development

(e) Consideration and being Compatible/complimentary with other Committed Plans

2) Formulation of the Drainage Planning Modules (or components)

(a) Selection of the Target Area for Detailed Drainage Planning

The target area proposed consists of Le Chan urban district, Ngo Quyen urban district, Old City Center within the Hong Bang urban district, two communes located in the south of Le Chan district and four communes located in the east of Ngo Quyen district. The total area covered is 5,240 ha.

The principal basis of the selection of the target area is the current and future population density, development trend and flood damage. The present and future population densities of the western half of Hong Bang district are quite low compared to the Old City Center of the district. The six non-urban communes are included in the target area because of their high present population density and strong possibility of being included in the urban district in near future.

(b) Division of the Target Area into Sub-areas

Based on drainage zoning, the total planning area is sub-divided into the following areas:

- Old City Center (OCC) Area, 857 ha: Discharge straight to rivers
- Central Area, 1275 ha: Discharge to lakes and NE and SW Channels
- New Urban Area (NUA), 3108 ha: Area where future urbanization is anticipated

(c) Appropriate Target Levels

a) Levels in Advanced Countries and other Cities in Vietnam

- In Japan, rainfall intensity with 5 to 10 year return period is used
- In the key cities in Vietnam, 5 to 10 year return period is adopted for both Hanoi and HCMC. Hanoi is the capital of the country and HCMC has the highest GRP. Both of the cities are bigger and have a higher status than Haiphong, which is the third largest city. In Hanoi, a 10 year ARI is adopted for trunk sewers discharging 30 km^2 area while a 5 year ARI is adopted for branch sewers

b) Levels Adopted in the other Study/plans for Haiphong

- 2 year ARI for the Central Area was used in the WB/FINNIDA plan

c) Adopted Target Levels at Grade A Level

OCC	no project, 2 year ARI, 5 year ARI
Central Area	5 year ARI, 10 year ARI
NUA	5 year ARI, 10 year ARI

It may be noted here that according to Vietnamese M/P, drainage priority is set as lowest for the old city area. It is proposed that no major action is required for that area. Since this river is tidal and there are many outlets in the old city center, it would be relatively costly and would take more time to improve the drainage level then in other areas.

(d) Relevance with other Sanitation Improvement/sewerage Development

Drainage projects/options for OCC and Central Area where combined sewers are existing would serve and be pre-requisite to the sewerage development if combined sewer based sewerage development is to be proposed in the Study for OCC and Central Area.

(e) Consideration and Compatibility/being Complementary with other Committed Plans

The drainage improvement plan by the WB and FINNIDA have been developed and make provisions for the Central Area. Thus options for the Central area should complement the existing plans for drainage improvement for this area and should be cost-effective.

The Central area is roughly divided into three drainage basins discharging into three canals. These are the Northeast and Southwest Drainage Basins, and parts of the An Kim Hai Channel Drainage Basin. The WB and FINNIDA plan includes improvement of both Northeast and Southwest Channels in addition to construction of two pumping stations and sewer and gate improvements. Thus, proposed measures such as the An Kim Hai Channel improvement would augment the WB/FINNIDA plan.

(f) Formulated Modules (or components) at Grade A Level

Sub-area	**No Action**	**2 Year ARI**	**5 Year ARI**	**10 Year ARI**
OCC	■	■	■	
Central Area			■	■
NUA			■	■

In total, there are 7 options (modules).

The three target areas, their beneficiary populations and the target improvement level for each module is given in the following table.

Catchment Area	**Area**	**Beneficiary (2020)**	**Target Level**
Old City Center	857 ha	121,452	No action
Old City Center	857 ha	121,452	Level C: 2 year ARI
Old City Center	857 ha	121,452	Level B: 5 year ARI
Central area	1275 ha	285,663	Level B: 5 year ARI
Central area	1275 ha	285,663	Level A: 10 year ARI
New Urban Area	3108 ha	167,561	Level B: 5 year ARI
New Urban Area	3108 ha	167,561	Level A: 10 year ARI
Total	**5240 ha**	**574,676**	--

(2) Formulation of Appropriate Drainage Improvement Planning Alternatives

Several alternatives for the drainage improvement master plan are proposed in this Study. These alternatives were formulated by selecting one module each for the three target planning areas as explained above. Thus, each alternative will have three modules. Within each alternative, different modules can have different target levels at different grade levels.

1) Formulation Criteria

(a) Central Area

Major formulation criteria for the Central Area are as follows:

- Most densely populated at present and in the future
- Most seriously affected by flooding

Therefore this area is the highest priority area for drainage improvement.

- Adopt the highest target level and implement during Phase I

(b) New Urban Area

Major formulation criteria for the New Urban Area are as follows:

- Relatively not seriously affected by flooding
- Relatively less population density at present
- Planned to develop quickly

Therefore, this area is the second highest priority area for drainage improvement.

- Same target level as central area but can be implemented in Phase II

(c) Old City Center

Major formulation criteria for the Old City Center are as follows:

- Seriously affected by flooding
- Densely populated but further development is planned to be restricted
- Altitude is low at about 2.5 m. Also, there are many outlets to the tide affected rivers. Sizable works would be needed to protect the Old City Center for levels of 5 year ARI or greater; need many tidal gates, pumping stations, and retarding basins; need ring dike for 10 year level, requiring long construction time and high cost
- In the previous and existing plans, no drainage plan is proposed

Therefore, this area is the third highest priority area for drainage improvement.

- One to two step lower level should be proposed for Old City Center, i.e., no project, 2 year or 5 year and Phase II implementation

2) Alternatives Formulation

Four alternatives for storm water drainage improvements have been proposed as shown below.

Alternatives for Drainage Improvement Master Plan in Class A Areas

	Target Area	**Target Drainage Level**	
		Grade A Level	**Grade B Level**
Alternative D1	Central Area New Urban Area Old City Center	5 Year ARI Storm 5 Year ARI Storm 2 Year ARI Storm	2 Year ARI Storm 2 Year ARI Storm 2 Year ARI Storm
Alternative D2	Central Area New Urban Area Old City Center	5 Year ARI Storm 5 Year ARI Storm 2 Year ARI Storm	2 Year ARI Storm 2 Year ARI Storm 2 Year ARI Storm
Alternative D3	Central Area New Urban Area Old City Center	10 Year ARI Storm 10 Year ARI Storm 2 Year ARI Storm	5 Year ARI Storm 5 Year ARI Storm 2 Year ARI Storm
Alternative D4	Central Area New Urban Area Old City Center	10 Year ARI Storm 10 Year ARI Storm 5 Year ARI Storm	5 Year ARI Storm 5 Year ARI Storm 5 Year ARI Storm

The details of each alternative are presented in the following sections. All cost estimates are of a preliminary nature at this stage. However, a similar benchmark was used to estimate costs, hence it is possible to compare costs of the various alternatives.

For the current alternative formulation, Old City Center is considered a relatively low priority in conformity with existing plans. In one option, this area is excluded altogether. In the other three options, however, it is included because of its high population density and economic importance.

Because of the shape of the drainage catchment the New Urban Area is divided into two catchments, namely east and west.

All options are divided into two phases. The Central Area is considered to be covered in Phase I. As the Old City Center is considered to have lowest priority due to small environmental impact on the river water quality to be caused by the discharges and is included in Phase II. New Urban Area is yet to be developed, this area is also included in Phase II.

(3) Drainage Alternative D1

Emphasis in D1 is given to the Central area in Phase I and New Urban Area in Phase II. The schematic diagram of this alternative is shown in Figure 3.5.1.

This option does not consider development of facilities and systems in the Old City Center in either phase.

1) Planning Criteria

The planning criteria for D1 are presented in the following table.

Planning Criteria for Drainage Option D1

Target Area	Area (km^2)	Target Drainage Level		Implementation
		Grade Level A	Grade Level B	
Central Area	12.75	5 year ARI	2 year ARI	Phase I
New Urban Area	31.08	5 year ARI	2 year ARI	Phase II

2) System and Facility Measures

The objective in Phase I is to rehabilitate An Kim Hai Channel as a drainage channel which will then connect the Northeast and Southwest Drainage Basins. Construction of Phuong Luu Lake is also included in the drainage system to increase the total storage capacity of the connected system.

In Phase II, development of the drainage systems in the New Urban Area will consist of construction of storage lakes, construction of tidal gates and storm water pumping stations, construction of new sewers, and rehabilitation of drainage channels.

The system and facility measures for D1 will then include the following.

(a) Rehabilitation of An Kim Hai Channel (Phase I)

- Excavation and embankment works of existing channel of length 10 km
- Construction of maintenance roads along both sides of the channel
- Demolition of one existing tidal gate
- Construction of two tidal gates and one discharge gate

(b) Construction of Phuong Luu Lake (Phase I)

- Excavation and embankment works of new lake
- Construction of roads and margins along the sides of the lakes
- Construction of connecting channel to Northeast Channel with length of 500 m and maintenance roads on both sides
- Construction of road connecting the lake site area to Highway No. 5
- Construction of concrete box culvert with gates at outlet discharging to An Kim Hai Channel

(c) Drainage Systems in New Urban Area (Phase II)

- Rehabilitation of drainage channels: 5,500 m
- Rehabilitation of 1 storage pond: 30,000 m^2
- Construction of 2 new storage lakes: total surface area 0.51 km^2
- Construction of 3 tidal gates
- Construction of 3 pumping stations: total capacity 27 m^3/s

- Construction of new sewers: 42,500 m

3) Timeframe

The timeframe for Phase I of Drainage Option D1 is estimated as 5 years. The total timeframe when including Phase II is 15 years.

4) Preliminary Costs Estimates

Preliminary costs estimates for D1 are presented in the following table.

Preliminary Costs Estimates for Drainage Option D1

Area	Preliminary Cost Estimate	Implementation
Central Area	US$17.5 million	Phase I
New Urban Area	US$55.0 million	Phase II
Total	**US$72.5 million**	

(4) Drainage Alternative D2

Emphasis in D2 is given to Central area in Phase I, and Old City Center and New Urban Area in Phase II. The schematic diagram of this alternative is shown in Figure 3.5.2.

1) Planning Criteria

The planning criteria for D2 are presented in the following table.

Planning Criteria for Drainage Option D2

Target Area	Area (km^2)	Target Drainage Level		Implementation
		Grade Level A	Grade Level B	
Central Area	12.75	5 year ARI	2 year ARI	Phase I
New Urban Area	31.08	5 year ARI	2 year ARI	Phase II
Old City Center	8.57	2 year ARI	2 year ARI	Phase II

2) System and Facility Measures

D2 is identical with D1 except that it has an additional emphasis in Phase II on upgrading drainage system of the Old City Center.

The objective for the Old City Center is to provide tidal gates and pumping stations to pump storm water during storms which occur at the same time as high tide. During high tide the tidal gates are closed to prevent tidal water intrusion in the sewer network to prevent silt build-up in the network. During a storm occurring at high tide, pumps will operate to dispose of storm water. In case of no sewerage intervention, the pumping stations will also include pumps dimensioned to pump dry weather sewage flows during high tide.

In the Old City Center, several outlets will be blocked and new main sewers to connect to the pumping stations will be implemented to minimize the amount of tidal gates and pumping stations.

In addition to the system and facility measures described for D1, D2 will include the following:

(a) Drainage System for Old City Center (Phase II)

- Construction of 5 pumping stations: total capacity 16 m^3/s
- Construction of 2 retarding basins: total surface area 82,500 m^2
- Rehabilitation of 2 storage lakes: total surface area 17,500 m^2
- Construction of discharge conduit, 2000x3000 mm: 300 m
- Construction of new sewers: 3,900 m
- Construction of 6 tidal gates

3) Timeframe

The timeframe for Phase I of Drainage Option D2 is estimated as 5 years. The total timeframe when including Phase II is 15 years.

4) Preliminary Cost Estimate

Preliminary costs estimates for D2 are presented in the following table.

Preliminary Costs Estimates for Drainage Option D2

Area	Preliminary Cost Estimate	Implementation
Central Area	US$17.5 million	Phase I
Old City Center	US$17.5 million	Phase II
New Urban Area	US$55.0 million	Phase II
Total	**US$90 million**	

(5) Drainage Alternative D3

Emphasis in D3 is given to Central Area in Phase I, and Old City Center and New Urban Area in Phase II. The schematic diagram of this alternative is shown in Figure 3.5.3.

1) Planning Criteria

The planning criteria for D3 are presented in the following table.

Planning Criteria for Drainage Option D3

Target Area	Area (km^2)	Target Drainage Level		Implementation
		Grade Level A	Grade Level B	
Central Area	12.75	10 year ARI	5 year ARI	Phase I
New Urban Area	31.08	10 year ARI	5 year ARI	Phase II
Old City Center	8.57	2 year ARI	2 year ARI	Phase II

2) System and Facility Measures

Drainage Option D3 is identical to D2 except drainage target levels for Central Area in Phase I and for New Urban Area in Phase II is higher, from Target Level B to Target Level A.

In addition to the system and facility measures for D2, D3 for the Central Area will include the following.

(a) Extra facilities for Integrated Drainage Zones (Phase I)

- Construction of 2 pumping stations at An Kim Hai Channel
- Construction of new main and branch sewers: 10,000 m

(b) Drainage System in the New Urban Area (Phase II)

- The systems and facilities for D3 for the New Urban Area will be the same, but designed for a storm with a 10 year ARI

3) Timeframe

The timeframe for Phase I of Drainage Option D3 is estimated as 5 years. The total timeframe when including Phase II is 15 years.

4) Preliminary Cost Estimate

Preliminary costs estimates for D3 are presented in the following table.

Preliminary Costs Estimates for Drainage Option D3

Area	Preliminary Cost Estimate	Implementation
Central Area	US$ 27.5 million	Phase I
Old City Center	US$ 17.5 million	Phase II
New Urban Area	US$ 80.0 million	Phase II
Total	**US$ 125 million**	

(6) Drainage Alternative D4

Emphasis in D4 is given to the Central Area and the Old City Center in Phase I, and the Old City Center and New Urban Area in Phase II. The schematic diagram of this alternative is shown in Figure 3.5.4.

1) Planning Criteria

The planning criteria for D4 are presented in the following table.

Planning Criteria for Drainage Option D4

Target Area	Area (km^2)	Target Drainage Level		Implementation
		Grade Level A	Grade Level B	
Central Area	12.75	10 year ARI	5 year ARI	Phase I
New Urban Area	31.08	10 year ARI	5 year ARI	Phase II
Old City Center	8.57	5 year ARI	5 year ARI	Phase II

2) System and Facility Measures

Drainage Option D4 is identical to D3 except that the drainage target level for the Old City Center in Phase II has been increased from Target Level C to Target Level B.

The systems and facilities for D4 will then be the same as D3, except that during Phase II, the capacities of the systems and facilities for the Old City Center will be greater, and additional tidal gates, pumping stations, and new main sewers will be implemented.

3) Timeframe

The timeframe for Phase I of Drainage Option D4 is estimated as 5 years. The total timeframe when including Phase II is 15 years.

4) Preliminary Cost Estimate

Preliminary costs estimates for D4 are presented in the following table.

Preliminary Costs Estimates for Drainage Option D4

Area	Preliminary Cost Estimate	Implementation
Central Area	US$27.5 million	Phase I
Old City Center	US$32.5 million	Phase II
New Urban Area	US$80.0 million	Phase II
Total	**US$140 million**	

(7) Comparison of Alternatives

An outline of the different alternatives is given in Table 3.5.1. The target area and drainage target levels of each alternative are compared in the following table.

Target Area and Drainage Target Levels of Each Option

	Phase I		Phase II	
	Target Area	Drainage Target Levels	Target Area	Drainage Target Levels
D1	Central Area	5 Year ARI	New Urban Area	5 Year ARI
D2	Central Area	5 Year ARI	Old City Center, New Urban Area	2 Year ARI, 5 Year ARI
D3	Central Area	10 Year ARI	Old City Center, New Urban Area	2 Year ARI, 10 Year ARI
D4	Central Area	10 Year ARI	Old City Center, New Urban Area	5 Year ARI, 10 Year ARI

The preliminary costs estimate is of each option compared in the following table.

Preliminary Costs Estimates of Each Option

	Phase I	Phase II	Total
D1	US$17.5 million	US$55.0 million	US$72.5 million
D2	US$17.5 million	US$72.5 million	US$90.0 million
D3	US$27.5 million	US$97.5 million	US$125.0 million
D4	US$27.5 million	US$112.5 million	US$140.0 million

The formulated alternatives are now compared.

1) Cost Comparison

A cost comparison of the formulated alternatives comprising the total investment cost and cost per beneficiary, is given in the following table. It

should be noted that implementation timings of the alternatives are the same and costs are in constant price terms.

Preliminary Costs Estimates of Each Planning Alternative

Alternative	Investment Cost	Cost per beneficiary
D1	US$72.5 million	US$170.33
D2	US$90 million	US$164.50
D3	US$125 million	US$228.48
D4	US$140 million	US$255.89

As shown in the table, the investment cost is lowest for D1 being followed by D2. The investment cost per beneficiary is lowest for D2 followed by D1.

2) Overall Comparison and Selection of the Optimum Drainage Improvement Plan

Assessment of the drainage master plan alternatives is given in Table 3.5.2. The formulated alternatives are compared from the following major points:

(a) Inclusion/exclusion of the Old City Center

(b) Selection of the most appropriate target level for each sub-area

(c) Appropriatephasing of the implementation of drainage improvement for each sub-area

After discussion with HPPC, in particular TUPWS, SADCO, PMU and the Steering Committee, the following assessment was made.

(a) It would be costly and least cost-effective to improve the Old City Center due to its low altitude and many outlets to the tidal river. The existing Haiphong Sewerage and Drainage Master Plan gives the Old City Center a low priority.

However, considering the current high population density as well as its importance as the administrative center of Haiphong City, the Old City Center should be included in the target area.

(b) Among the various target levels for drainage improvement, rainfall intensity of 5 year return period for Grade A Level facilities is considered most appropriate except for the Old City Center considering:

- These levels adopted for advanced countries and these for the capital city of Hanoi and Ho Chi Minh City with the biggest GRP range from 5 to 10 years
- The higher target level of 10 years would require a lager capital outlay and cost per beneficiary, though the higher the better from the viewpoint of achieving sanitary environment

A two-year target level for Grade A Level facilities should be adopted for the Old City Center considering the high cost per beneficiary.

(c) Considering the high total investment cost required for the drainage improvement of the whole target area, the drainage improvement plan should be implemented in phases. Considering seriousness of past flood occurrence and future flood damage, and that it has the highest present and projected population density among the sub-areas, the Central Area should be the first to be improved among the sub-areas of the target area. The other sub-areas should follow in the second phase.

Consequently, alternative D2 has been selected as the optimum plan for drainage improvement of the target area.

3) Characteristics and Merits of the Selected Alternative D2

Drainage Option D2 is selected as the optimum measure for Class A area. The basis for this selection includes the following:

- Complete coverage of the planning area
- Target drainage levels are adequate
- Most cost effective for largest coverage

The selected alternative D2 covers the whole of the target area of 5,240 ha including the Old City Center with 575,000 inhabitants. It would also be the most cost effective at US$164.5 per beneficiary.

3.5.2 Preliminary Design and Cost Estimates for the Selected Alternative

(1) Central Area

Selected storm water drainage improvements for the Central Area include the following main components:

- Rehabilitation of An Kim Hai Channel
- Construction of Phuong Luu Lake

The main components and given conditions are presented in Figure 3.5.5.

The components are proposed to be implemented in Phase I to achieve Drainage Target Level B for Grade Level A facilities.

1) Rehabilitation of An Kim Hai Channel

Rehabilitation of An Kim Hai Channel includes the following components:

- Excavation and embankment works of the existing channel for the length of 10 km
- Construction of maintenance roads along both sides of the channel

- Demolition of the existing tidal gate
- Construction of two tidal gates and one discharge gate

(a) Preliminary Design Approach

The preliminary design channel rehabilitation is based on the following approach:

- During high tide the hydraulic capacity of the rehabilitated channel should be such that when the tidal gates are closed, water will flow from the channel to the lakes
- During low tide the hydraulic capacity of the rehabilitated channel should be such that when the tidal gates are opened, water will flow from the lakes in the channels to the opened tidal gates

(b) Preliminary Design Parameters

The following channel design dimensions are proposed:

- One stage trapezoidal cross-sectional shape
- Bottom level of channel: +0.5 m
- Lining of the channel side-slopes with rubble masonry revetment
- Side-slope of channel on both sides: 1:1.25
- Width of maintenance road and margin on both sides: 5 m
- Top width of channel is maximized according to existing conditions

Costs estimates are based on the channel layout according to the above criteria with channel top widths as presented in the following table.

Locations and Lengths of Channel Design Sections

Location	Length	Top Width
From Lach Tray Tidal Gate to Du Hang Lake	1,900 m	12 m
From Du Hang Lake to Ha Doan Road	6,550 m	15 m
From Ha Doan Road to Cam River Tidal Gate	1,700 m	20 m

2) Construction of Phuong Luu Lake

Construction of Phuong Luu Lake includes the following components:

- Excavation and embankment works of new lake
- Construction of roads and margins along the sides of the lakes
- Construction of a connecting channel to the Northeast Channel with a length of 500 m and maintenance roads on both sides
- Construction of road connecting the lake site area to Highway No. 5

- Construction of concrete box culvert with gates at outlet discharging to An Kim Hai Channel

(a) Preliminary Design Approach

Preliminary design of Phuong Luu Lake is based on the following approach:

- According to the planning criteria in the Haiphong Sewerage and Drainage Master Plan the minimum water level of the new lake would be +1.5 m and the maximum water level+2.7 m
- Rehabilitation of the existing lakes in the Central Area have been designed for a maximum water level of +2.9 m in the World Bank Sanitation Project, except for Sen Lake, which has a maximum water level of +3.2 m
- The required storage capacity and lake surface area were based on a design storm with 5 Year ARI and rainfall runoff based on the rational method for a projected degree of developed land area in Year 2010

Phuong Luu Lake is constructed with the objective of integrating the three separate drainage basins in the Central Area. As a given condition, there are two pumping stations in the integrated drainage basin, each with a capacity of 9 m^3/s, or a total combined capacity of 18 m^3/s.

(b) Design Catchment Areas

Based on existing conditions, the integrated drainage system consists of the following drainage basins and associated land surface areas:

- Northeast Drainage Basin: 600 ha surface area
- Southwest Drainage Basin: 400 ha surface area
- An Kim Hai Channel Drainage Basin: 840 ha surface area

The three drainage basins are presented in Figure 3.5.6.

For the World Bank Project, the rehabilitation designs of Northeast and Southwest Channels were based on the inclusion of two 50 ha catchment areas in the An Kim Hai Channel Drainage Basin.

(c) Design Storm Analysis

A 12 hour storm duration was used for the analysis. Design storm hyetographs were developed using data for storms which occur with average recurrence intervals of 5 years. The hyetographs were developed using a "Balanced Storm Approach". In this method the storm depth at any duration of storm is equal to the depth from the intensity-duration-frequency curves. In this analysis, 15 minute intervals were used to develop hourly rainfall amounts during a 12 hour storm.

The method was applied as follows for the 4 hours during the middle of a design storm. The calculated rainfall for the 5 Year ARI storm in the first 15 minutes of the storm 35 mm. The total depth after 30 minutes is 50 mm. The incremental depth from 15 to 30 minutes is then 15 mm. The method continues using polynomial interpolation for the 15 minute intervals to give 16 incremental rainfall depths for each 15 minutes.

These depth increments are then arranged so that the most intense increment is at the center of the storm. The second most intense is placed before this peak. The third most intense is placed after it, the fourth before the second increment, and so on. The method is completed by staggering the placement of all the increments until all 16 increments are placed alternatively in front or at the end of the storm. The 15 minute intervals are then summed to provide hourly rainfall depths for the design storm hyetographs.

The results of calculations for the design storm hyetograph for the 4 hours during the middle of the storm duration are presented in the following table.

Design Storm Hyetograph Data for Storm of 5 Year ARI

time (min)	rainfall depth (mm)	increment (mm)	Arranged increment (mm)	hourly depth (mm)
0	0	0	0	
15	35	35	2	
30	50	15	3	
45	64	14	3	
60	75	11	4	12
75	85	10	6	
90	94	9	9	
105	101	7	11	
120	107	6	15	41
135	112	5	35	
150	116	4	14	
165	120	4	10	
180	123	3	7	66
195	126	3	5	
210	129	3	4	
225	131	2	3	
240	133	2	2	14

For the remaining 8 hours of the storm, the hourly rainfall amounts are distributed uniformly, so that the total rainfall amount for the 12 hour storm is 175 mm.

For the design storm, the moment of greatest rainfall intensity occurs when the tide level is at the highest level a 10 year ARI. Based on this criteria the maximum water level is +4.1 m and the minimum water level is +1.0 m. The

developed storm hyetograph and corresponding tidal levels are presented in Figure 3.5.7.

(d) Design Storage Capacity

The rainfall runoff in the drainage basins was based on the Rational Method formula as follows.

$$Q = (1/360) * C * I * A$$

Where Q : *Rainfall runoff* (m^3/s)

C : *Runoff coefficient*

I : *Rainfall intensity (mm/hr)*

A : *Catchment area (ha)*

Calculations for specific storage and pump capacities were performed by using the formula as follows.

$$\sum Qin - \sum Qout = \sum S$$

$$Qin = 60 * Q * T$$

$$Qout = 60 * q * T$$

Where Qin : *Runoff volume* (m^3)

$Qout$: *Pump drainage volume* (m^3)

Q : *Rainfall runoff* (m^3/s)

q : *Pumping capacity* (m^3/s)

T : *Calculation time (15 min.)*

The spatial size of the catchment areas, which collectively form the three drainage basins, are large. In order to accurately include the effects of overland flow of the rainfall runoff and hydrodynamic flow in the drainage channels, the following basis was adopted:

- After 60 minutes 25% of the runoff will drain into the lakes
- After 75 minutes 25% of the remaining runoff will drain into the lakes
- After 90 minutes 25% of the remaining runoff will drain into the lakes
- After 120 minutes 25% of the remaining runoff will drain into the lakes

For example, at time *(t = t + 8)*, the amount of runoff draining into the lakes is calculated as follows.

$$Q^{t=t+8} = 0.25 * Q^{t=t+1} + 0.25 * Q^{t=t+2} + 0.25 * Q^{t=t+3} + 0.25 * Q^{t=t+4}$$

This approach then provides a storage capacity analysis based on a total flow time of two hours for the rainfall runoff to drain into the storage lakes

(e) Design Runoff Coefficients

Design runoff coefficients were based on the amounts of developed and undeveloped land in the catchment areas, using the criteria presented in the following table.

Criteria for Calculating Composite Design Runoff Coefficients

Degree of Land Development	Runoff Coefficient	
	Developed Land	Undeveloped Land
90% - 100%	0.60	0.30
80% - 90%	0.55	0.25
70% - 80%	0.50	0.20
50% - 70%	0.45	0.15
30% - 50%	0.40	0.10
10% - 30%	0.30	0.05

Based on this criteria, composite runoff coefficients were calculated using the following formula.

$$C_{COMPOSITE} = \frac{\sum \left(C_{SUB-AREA} \times AREA_{SUB-AREA} \right)}{\sum AREA_{SUB-AREA}}$$

For determining the composite runoff coefficient for the total drainage basin area of 18.4 km^2, the system was divided into six sub-basins consisting of the Northeast and Southwest Drainage Basin, and five sub-basins in the An Kim Hai Channel Drainage Basin. For each of the six sub-basins, a composite runoff coefficient was then calculated according to the amount of developed and undeveloped land projected for the Year 2010 for the ward and commune areas within these six sub-basins.

Land development data are presented in Table 3.5.3 for the Northeast and Southwest Drainage Basins and Table 3.5.4 for the An Kim Hai Channel Drainage Basin. Based on these data, the land area and composite runoff coefficient of each sub-basin are presented in the following table.

Runoff Coefficients of Drainage Sub-Basins

Sub-Basin	Land Area (ha)	Runoff Coefficient	Area*Coefficient
NE and SW Basin	1,000	0.473	473
Sub-Basin AK-1	70	0.575	40
Sub-Basin AK-2	160	0.523	84
Sub-Basin AK-3	120	0.498	60
Sub-Basin AK-4	310	0.265	82
Sub-Basin AK-5	180	0.128	23
TOTAL	**1,840**		**762**

The overall composite runoff coefficient for the total integrated drainage basin of 1,840 ha was calculated on 0.414 (= 762/1,840).

(f) Results of Design Calculations

Based on the total catchment area of 18.4 km^2 the specific pump capacity is 0.98 m^3/s /km^2. Results of calculations for specific storage requirement is presented in Figure 3.5.8.

As indicated in Figure 3.5.8, the specific storage needed is 42,416 m^3/km^2. The pumping duration would be 1,200 minutes or 20 hours.

The catchment area of 18.4 km^2, means that 780,455 m^3 of storage capacity is needed. The following table presents the storage capacities of the existing lakes in the total integrated drainage basin, according to the adopted planning criteria.

Storage Capacities of Existing Lakes in Total Integrated Drainage Basin

Lake	Surface Area (ha)	Regulated Depth (m)	Storage Capacity (m3)
Tien Nga Lake	2.3	1.4	32,200
An Bien Lake	20.0	1.4	280,000
Mam Tom Lake	2.1	1.4	29,400
Quan Ngua Lake	2.5	1.4	35,000
Du Hang Lake	4.6	1.4	64,400
Lam Tuong Lake	2.0	1.4	28,000
Sen Lake	2.0	1.7	34,000
Total	**35.5**		**503,000**

From the calculations for needed and existing storage capacities, the new lake should provide an additional 277,455 m^3 storage capacity. Based on a regulated water depth of 1.2 m (minimum water level of +1.5 m and maximum water level of +2.7 m), the surface area of the new lake is planned to be 24 ha. The total site area (including the lake, roads, sidewalks and recreational areas) is then estimated as 28 ha.

(g) Needed Works for Integration of Drainage Basins

Integration of the three drainage basins is to be achieved by connecting the proposed Phuong Luu Lake with the Northeast Channel and An Kim Hai Channel. An open channel would be used for the connection to the Northeast Channel whilst a closed conduit is needed for the connection with An Kim Hai Channel.

Cost estimates for the connecting channel is based on a channel top width of 15 m, channel side-slopes of 1:1.25, maintenance roads and margins of total width of 7 m, and a total length of 500 m.

Cost estimates for the closed conduit connection to An Kim Hai Channel is based on a box culvert with dimensions of 3 x (3000 mm x 2000 mm) and a

total length of 450 m. Three discharge gates will be located at the outlet to An Kim Hai Channel. A road connecting the lake site area to Highway No. 5 will be constructed above the box culvert. The length of the planned road is 400 m and the total width (including road and sidewalks) is 12 m.

3) Supplementary Components

(a) New Combined Sewers

Rehabilitation of the existing combined sewer network is a given condition because sewer rehabilitation works are included in the World Bank Sanitation Project.

However, construction of new combined sewers is included as a supplementary component in Phase I where:

- Existing sewers are not covered by the rehabilitation works of the World Bank Project
- New sewers will not be constructed the World Bank Project, but will e needed after construction of new roads in the Central Area

Replacement of 3 km of new main sewers and construction of 7 km of new branch sewers to connect to the main sewers of the new roads are provided as supplementary components.

Also, an additional 10 km of new sewers for the Central Area is included in Phase II, to achieve the target sewerage density.

(b) Channel Road Bridges

At present there are 10 road bridges and 21 small wooden and bamboo bridges which cross over An Kim Hai Channel. The small foot bridges will need to be removed. However, the main road bridges do not need to be removed.

Consequently, the Drainage Priority Project includes the construction of new bridges over An Kim Hai Channel as a supplementary component. A t otal of 15 bridges is included, 3 with a length of 12 m, 9 with a length of 15 m, and 3 with a length of 20 m. The width of all new bridges is 7 m.

(c) Ancillary Works

Ancillary works are also included in the Priority Project as a supplementary component. The ancillary works consist of lighting of the roads and margin areas by light poles and lamps, metal fences along the edges of the channel and lake roads, and trees and other plantings in the margin areas of the channels and lake.

(2) Old City Center

Selected storm water drainage improvements for the Old City Center include the following main components:

- Construction of 5 pumping stations: total capacity 16 m^3/s
- Construction of 2 retarding basins: total surface area 82,500 m^2
- Rehabilitation of 2 storage ponds: total surface area 17,500 m^2
- Construction of box sewer, 2000x3000 mm: length 300 m
- Construction of new sewers: total length 10,000 m
- Construction of 6 tidal gates

The components are proposed to be implemented in Phase II to achieve Drainage Target Level C for both Grade A and Grade B Levels for a storm with 2 year ARI and a tide level with a 10 year ARI.

1) Preliminary Design Approach

Preliminary design for drainage development in the Old City Center is based on the following approach:

- During high tide, gravity flow in the sewer system is not possible for the design storm, resulting in flooding. Consequently, pumping stations are needed to pump out storm water during high tide
- In order to minimize total costs, existing lakes or new retarding basins will be used in conjunction with pumping stations to reduce the capacities and investment costs of the pumping stations
- The needed pumping and pond storage capacities are based on a design storm with a 2 Year ARI and rainfall runoff based on the rational method for the projected degree of developed land area in the year 2020

In the Old City Center, six catchment areas have been defined as follows:

- Thuong Ly 1 Ward: Area of Thuong Ly Ward north of Bach Dang Street
- Thuong Ly 2 Ward: Area of Thuong Ly Ward south of Bach Dang Street
- Trai Chuoi Ward: Area of Trai Chuoi Ward
- Ha Ly Ward: Area of Ha Ly Ward, north and south of Bach Dang Street
- Haiphong City Center: Area in Hong Bang, Le Chan and Ngo Quyen Districts bordered by Tam Bac River and north of railways
- May Chai Ward: Area of May Chai Ward draining directly to Cam River (81% of the area, remaining area drains to Northeast channel)

Individual solutions are then proposed for each of the six catchment areas.

2) Design Storm Analysis

A 12 hour storm duration was used for the analysis. Design storm hyetographs are developed using data for storms which occur with average recurrence intervals of 2 years. The hyetographs are developed using a "Balanced Storm Approach". This approach is identical to the approach used for preliminary design of Phuong Luu Lake.

The results of calculations for the design storm hyetograph for four hours during the middle of the storm duration are presented in the following table.

Design Storm Hyetograph Data for Storm of 2 Year ARI

time (min)	rainfall depth (mm)	increment (mm)	arranged (mm)	hourly depth (mm)
0	0	0	0	
15	30	30	1	
30	45	15	1	
45	53	8	2	
60	59	6	2	6
75	63	4	3	
90	67	4	4	
105	70	3	6	
120	73	3	15	28
135	76	3	30	
150	78	2	8	
165	80	2	4	
180	82	2	3	45
195	84	2	3	
210	85	1	2	
225	86	1	2	
240	87	1	1	8

For the remaining 8 hours of the storm, the hourly rainfall amounts are distributed uniformly, so that the total rainfall amount for the 12 hour storm is 112 mm.

For the design storm, the moment of greatest rainfall intensity occurs when the tide level is at the highest level with a 10 year ARI. Based on this criteria the maximum water level is +4.1 m and the minimum water level is +1.0 m. The developed storm hyetograph and corresponding tidal levels are presented in Figure 3.5.9.

3) Preliminary Design Runoff, Pumping and Storage Capacity Calculations

The design discharge of the catchment area was calculated using the Rational Method formula as described in the preliminary design of Phuong Luu Lake.

Table 3.5.5 includes data on the percentage of developed area in the Old City Center. From Table 3.5.5, the areas in each of the catchments and the projected area of developed land for the year 2020 are presented in the following table.

Projected Development Areas in Year 2020 for Old City Center

Catchment Area	Area (km^2)	Developed Area in Year 2020 (km^2)	% Developed Area of Total Area
Thuong Ly 1 Ward	1.11	1.11	100%
Thuong Ly 2 Ward	0.47	0.47	100%
Trai Chuoi Ward	0.43	0.36	84%
Ha Ly Ward	1.06	0.92	87%
Haiphong City Center	2.54	2.46	97%
May Chai Ward	1.88	1.43	76%
Total	**7.49**	**6.75**	**95%**

Determination of the composite runoff coefficients used the same approach and criteria as for Phuong Luu Lake.

The composite runoff coefficients for each of the catchment areas are summarized in the following table.

Design Runoff Coefficients for Old City Center

Catchment Area	Composite Run-off Coefficient
Thuong Ly 1 Ward	0.600
Thuong Ly 2 Ward	0.600
Trai Chuoi Ward	0.502
Ha Ly Ward	0.495
Haiphong City Center	0.591
May Chai Ward	0.428

For Thuong Ly 1 Ward the following measures are proposed:

- A tidal gate, pumping station, and retarding basin are to be constructed on low land near the Cam River
- New main sewers (total length: 1,500 m) are to be constructed and connected to the retarding basin and pumping station

For Thuong Ly 2 Ward the following measures are proposed:

- An existing lake in the catchment area is to be rehabilitated as a retarding basin. The existing surface area of this lake is estimated as 20,000 m^2. A tidal gate and pumping station are to be located at the discharge point of the lake
- The existing lake is connected to a small channel with a tidal gate at the outlet to the Ha Ly River. A box culvert (dimensions 3000 x 2000 mm and length 300 m) for pumping station is to be constructed in channel

- New main sewers (total length: 500 m) are to be constructed in the area and connected to the retarding basin and pumping station

For Trai Chuoi Ward the following measures are proposed:

- An existing lake in the catchment area is to be rehabilitated as a retarding basin. The existing surface area of the lake is estimated as 1 ha. A tidal gate and pumping station are to be located at the discharge point of the lake
- New main sewers (total length: 800 m) are to be constructed in the area and connected to the retarding basin and pumping station

For Ha Ly Ward the following measures are proposed:

- A tidal gate, pumping station, and retarding basin are to be constructed
- The housing density in this area is high. Surface area of the retarding basin is minimized by allowing temporary flooding to 15 cm depth over 15 % of the area in order to minimize the need for land acquisition and resettlement of affected households
- New main sewers (total length: 1,500 m) are to be constructed in the area and connected to the retarding basin and pumping station

For Haiphong City Center the following measures are proposed:

- New main sewers (total length: 5,000 m) are to be constructed to drain he whole catchment area to Tam Bac Lake. New sewers are to located on Trung Hung Dao Street, Tran Phu Street, and Dinh Tien Hoang Street
- A tidal gate and pumping station are to be constructed and connected to Tam Bac Lake, which would then function as a retarding basin. The surface area of Tam Bac Lake is estimated as 5.8 ha

For May Chai Ward the following measures are proposed:

- A tidal gate will be constructed at the sewer outlet to the Cam River for the sewer on Le Lai Street. The tidal gate will be constructed using a sluice gate
- A new sewer (length: 700 m) will be constructed which will connect the existing sewer on Le Lai Street to the Northeast channel
- During high tide, the tidal gate will be closed. During dry weather conditions, the closed tidal gate will prevent water to flow from the Cam River to the Northeast Channel. During storm, conditions, the closed tidal gate will cause storm water to be discharged to the Northeast Channel system, from where the storm water will be pumped by the pumping station located at May Den Tidal Gate

- During low tide, and dry weather conditions, the tidal gate will be closed to prevent water from being discharged from the Northeast Channel to the Cam River. However, during low tide and storm, conditions, the tidal gate can be opened to allow direct discharge of storm water from the area to the Cam River
- Calculations for specific storage and pump capacities adopted the same approach as that of the preliminary design of Phuong Luu Lake. Results for the calculations are shown in the following table

Proposed Pumping Station and Retarding Basin Parameters for Old City Center

Catchment Area	Pumping Capacity (m^3/s)	Storage Capacity (m^3)	Regulation Depth (m)	Surface Area (m^2)	Pumping Operation (hr)
Thuong Ly 1	4.0	32,000	1.5	21,500	8.0
Thuong Ly 2	1.5	15,000	1.5	10,000	8.5
Trai Chuoi	1.5	11,000	1.5	7,500	7.0
Ha Ly	4.0	30,000	1.5	3,000	7.0
Haiphong City Center	6.0	87,000	1.5	58,000	8.0

From the table the systems are operated at a regulation depth of about 1.5 m. For all systems the design minimum depths are +1.0 m.

(3) New Urban Area

Selected storm water drainage improvements for the New Urban Area include the following main components:

- Rehabilitation of drainage channels: total length 5,500 m
- Rehabilitation of 1 storage pond: surface area 30,000 m^2
- Construction of 2 new storage lakes: total surface area 0.51 km^2
- Construction of 3 tidal gates
- Construction of 3 pumping stations: total capacity 27 m^3/s
- Construction of new sewers: total length 77,000 m

The components are proposed to be implemented in Phase II to achieve the following targets:

- Drainage Target Level B with a storm of 5 year ARI for Grade A Level facilities (storage lakes, channels, and pumping stations)
- Drainage Target Level C with a storm of 2 year ARI for Grade B Level facilities (main and lateral storm water sewers)
- For both drainage target levels, high tide levels with a 10 year ARI ware applied

1) Preliminary Design Approach

The preliminary design for drainage development in the New Urban Area was based on the following approach:

- The extent of the planning area is large and gravity drainage to local rivers is not possible. Drainage of the area therefore must be achieved with channels, storage lakes, and pumping stations
- The needed pumping and pond storage capacities are based on design storm with a 5 Year ARI and rainfall runoff based on the rational method for projected developed area in Year 2020
- The system is to be implemented in Phase II hence land development patterns are projected and not certain. However, the present sewer density is very low in the area, and new sewers for drainage will be needed in Phase II. New main sewers are included in Phase II and will be based on an appropriate target for sewer density in the year 2020

Based on projected land development patterns, the New Urban Area will be divided into 3 main catchment areas for drainage system development as follows:

- Cat Bi Area: Cat Bi Ward
- Southwest Extension Area: New Urban Area west of Lach Tray Street extending to Lach Tray River
- Southeast Area: New Urban Area east of Lach Tray Street extending to Cam River

2) Design Storm Analysis

For the analysis a 12 hour storm duration is selected. Design storm hyetograph and tide levels are equivalent to the hyetograph and tide levels used for preliminary design of Phuong Luu Lake.

3) Preliminary Design Runoff, Pumping and Storage Capacity Calculations

The design discharge of the catchment area is based on the Rational Method formula as described in the preliminary design of Phuong Luu Lake. Determination of the runoff coefficients is based on the same approach and criteria as for Phuong Luu Lake.

(a) Cat Bi Area

For Cat Bi Area the following measures are proposed:

- Existing ponds in the catchment area are to be rehabilitated as a retarding basin with discharge to the Lach Tray River

- A tidal gate and pumping station are to be constructed at the discharge point of the retarding basin to the Lach Tray River
- New main sewers are to be constructed in the area and connected to the retarding basin and pumping station

For Cat Bi Ward the total area is 1.29 km^2 and the projected developed area in 2020 is 1.24 km^2. The percentage of projected developed area is 96 % yielding runoff coefficient of 0.588.

Calculations for specific storage and pump capacities were done using the same approach as for preliminary design of Phuong Luu Lake. Results for the calculations are as follows:

- Storage pond capacity: 45,000 m^3
- Regulation depth: 1.5 m
- Surface area of pond: 30,000 m^2
- Pumping station capacity: 3.0 m^3/s
- Pumping station operation: 10 hours

It is estimated that 2,000 m of new sewers are needed in the area to connect the existing sewer network to the retarding basin and pumping station.

(b) Southwest Extension Area

For the Southwest Extension Area the following measures are proposed:

- A new storage lake is to be constructed near the Lach Tray River
- An existing channel which would connect the new Don Nghia Lake to the Lach Tray River will be rehabilitated and extended
- A tidal gate and pumping station are to be constructed at the outlet of the rehabilitated channel to the Lach Tray River
- New sewers will be constructed for the developed areas. The amount of new sewers is based on an appropriate target for sewer density in the Year 2020

Table 3.5.6 includes data on the percentage of developed land area in the New Urban Area. Areas associated with the New Urban Area, but located in the An Kim Hai Channel Drainage Basin, are not included in the table.

From Table 3.5.6, the land areas in the Southwest Extension Area, as well as the projected developed land areas for the Year 2020, are presented in the following table.

Projected Development Areas in Year 2020 for Southwest Extension Area

Land Area	Area (km2)	Developed Area in Year 2020 (km2)	% Developed Area of Total Area
Du Hang Kenh Commune	0.67	0.59	88%
Vinh Niem Commune	3.77	2.60	69%
Total	**4.44**	**3.19**	

For Du Hang Kenh Commune a composite runoff coefficient of 0.514 is calculated, and for Vinh Niem Commune a value of 0.357 is calculated. This gives a composite runoff coefficient of 0.381 for the Southwest Extension Area comprising these two areas.

Calculations for specific storage and pump capacities were done using the same approach as for the preliminary design of Phuong Luu Lake. Results for the calculations are as follows:

- Storage lake capacity: 202,500 m^3
- Regulation depth: 1.5 m
- Surface area of lake: 0.135 km^2
- Pumping station capacity: 6.0 m^3/s
- Pumping station operation: 10.5 hours

The rehabilitated channel which would connect the new lake with An Kim Hai Channel and Lach Tray River would have the following dimensions:

- Total length: 1,500 m
- One stage trapezoidal cross-sectional shape
- Bottom level of channel: +0.5 m
- Rubble masonry lining of the channel side-slopes
- Side-slope of channel on both sides: 1:1.5
- Width of maintenance margins: 5 m
- Top width of channel: 18 m

The existing amount of sewers in the developed land areas in the Old City Center and Central Area is about 170 km. The present developed area in these city areas is about 16.75 km^2. The existing sewer density is then about 10 km/km^2.

For the Southwest Extension Area it is estimated that the land development will require a target sewer density in the year 2020 which is about 70 % of the

sewer density in the existing developed areas. This target sewer density is then 7.0 km/km^2.

The amount of developed area for the Southwest Extension Area is 3.19 km^2 by the Year 2020. Consequently, it is estimated that 22,000 m of new sewers (diameter 800 mm to 2000 mm) are needed in Phase II for this area.

An additional 3,000 m of new sewers is included for parts of An Kim Hai Channel Drainage Basin that are located in the Southwest Area of the New Urban Area.

(c) Southeast Area

For the Southeast Area the following measures are proposed:

- An existing channel located alongside Ngo Gia Tu Road that extends from the Trang Cat Landfill will be rehabilitated. The discharge point is into the Cam River near the Trang Cat Landfill
- Another channel existing connects An Kim Hai Channel to a middle part of the channel located alongside Ngo Gia Tu Road. This channel will be rehabilitated so that the middle part contains a new storage lake and either end would connect to An Kim Hai Channel and to the middle part of the rehabilitated channel alongside Ngo Gia Tu Road
- A tidal gate and pumping station will be constructed and located at the can River outlet of the rehabilitated Ngo Gia Tu Road channel near Trang Cat Landfill
- New sewers will be constructed for the developed areas. The amount of new sewers is based on an appropriate target for sewer density in the year 2020

Table 3.5.6 includes data on the percentage of developed land area in the New Urban Area. Areas associated with the New Urban Area, but located in the An Kim Hai Channel Drainage Basin, are not included in the table.

From Table 3.5.6 the land areas in the Southeast Area, as well as the projected developed land areas for the year 2020, are presented in the following table.

Projected Development Areas in Year 2020 for Southeast Area

Land Area	Area (km2)	Developed Area in Year 2020 (km2)	% Developed Area of Total Area
Dang Giang Ward	0.15	0.14	96%
Dong Quoc Bing Ward	0.11	0.11	100%
Dong Hai Commune	7.90	5.14	65%
Dang Lam Commune	4.34	3.78	87%
Dang Hai Commune	1.37	0.70	51%
Nam Hai Commune	17.25	5.52	32%
Total	**31.12**	**15.39**	

Based on the planning criteria, the following composite runoff coefficients were calculated for each sub-area:

- Dang Giang Ward: 0.588
- Dong Quoc Bing Ward: 0.600
- Dong Hai Commune: 0.345
- Dang Lam Commune: 0.511
- Dang Hai Commune: 0.303
- Nam Hai Commune: 0.196

For the Southeast Area, which comprises the six sub-areas, the composite runoff coefficient was thus calculated as 0.286.

Calculations for specific storage and pump capacities used the same approach as the preliminary design of Phuong Luu Lake. Results for the calculations are as follows:

- Storage lake capacity: 562,500 m^3
- Regulation depth: 1.5 m
- Surface area of lake: 0.375 km^2
- Pumping station capacity: 18 m^3/s
- Pumping station operation: 16.5 hours

The rehabilitated section of the channel alongside Ngo Gia Tu Road which would connect the new lake with An Kim Hai Channel and the outlet to the Cam River near the Trang Cat Landfill would have the following dimensions:

- Total length: 2,000 m
- One stage trapezoidal cross-sectional shape
- Bottom level of channel: +0.5 m
- Rubble masonry lining of the channel side-slopes
- Side-slope of channel on both sides: 1:1.5
- Width of maintenance margins: 5 m
- Top width of channel: 30 m

The rehabilitated remaining section of the channel alongside Ngo Gia Tu Road extending in the west direction will have the following dimensions:

- Total length: 2,000 m
- One stage trapezoidal cross-sectional shape
- Bottom level of channel: +0.5 m
- Rubble masonry lining of the channel side-slopes
- Side-slope of channel on both sides: 1:1.5

- Width of maintenance margins: 5 m
- Top width of channel: 24 m

The existing sewers in the developed land areas in the Old City Center and Central Area amount to about 170 km. The present developed area in these city areas is about 16.75 km^2, hence the sewer density is about 10 km/km^2.

For the Southeast Area it is expected that the land development will require a target sewer density in the year 2020 that is about 40 % of the sewer density in the existing developed areas of Old City Center and NE and SW channel systems. This target sewer density is then 4.0 km/km^2.

The projected area of land development in the Southeast Area where drainage intervention is needed, is 9.87 km^2 by the year 2020 (land in Nam Hai Commune is not included because the projected degree of land development is less than 40 %). Consequently, it is estimated that 40,000 m of new sewers (diameter 800 mm to 2000 mm) are needed in Phase II for this area.

An additional 10,000 m of new sewers is included for parts of An Kim Hai Channel Drainage Basin which are located in the Southeast Area of the New Urban Area.

(4) Summary of Project Components

The components and quantities for Phase I are summarized in the following table.

Main Components and Quantities in Phase I Works

Component	Unit	Amount
Rehabilitation of existing channels	m	10,000
Construction of new channel	m	500
Construction of channel maintenance roads	m	21,000 m
Construction of new storage lake	ha	24
Construction of lake site area and roads	ha	4
Construction of access road to lake	m	400 m
Box culvert 3 x (3000 mm x 2000 mm)	m	450 m
Tidal gates and structures	nrs.	2
Discharge gates and structures	nrs.	2

In addition, supplementary components are also included in Phase I. The scope of works are presented in the following table.

Supplementary Components and Quantities in Phase I Works

Component	Unit	Amount
New main and lateral sewers	m	10,000
Channel road bridges	nrs.	15
Ancillary works for channels	m	21,000
Ancillary works for lake site area	ha	4

The components and quantities for Phase II are summarized in the following table.

Main Components and Quantities in Phase II Works

Component	Unit	Amount
Construction of new storage lake 1	ha	37.5
Construction of new storage lake 2	ha	13.5
Pumping station, 18 m^3/s	nrs.	1
Pumping station, 6 m^3/s	nrs.	2
Pumping station, 4 m^3/s	nrs.	2
Pumping station, 3 m^3/s	nrs.	1
Pumping station, 1.5 m^3/s	nrs.	2
Construction of retarding basins	nrs.	2
Tidal gates and structures	nrs.	9
Rehabilitation of storage lakes	nrs.	3
New main and lateral sewers	m	87,000
Box sewers 3000x2000 mm	m	300
Rehabilitation of channels	m	5,500

(5) Cost Estimates

The drainage facilities are shown in Figure 3.5.10. The facilities cost is given in Table 3.5.7. The list includes costs of new facilities proposed in the Master Plan for Class A area. This list also includes costs of facilities proposed by the World Bank and FINNIDA Projects.

The cost of World Bank and FINNIDA Projects is US$32.8 million. The cost of newly proposed project is US$116.4 million for Class A area.

(6) Land Acquisition and Compensation

Required land acquisition for the implementation of the project is given in Table 3.5.8. The total agricultural land loss is 85.9 ha, residential land loss is 7.9 ha and house loss is 1,478 houses. For Phase I, the figures are 34 ha, 5.3 ha and 1,300 houses, respectively. Total compensation would amount to US$8.46 million, of which, Phase I compensation is US$3.7 million.

3.6 Preliminary Design and Cost Estimates for Measures for Class B Area

3.6.1 Preliminary Design of the System and Facility

The outline drainage proposal for Kien An District is provided on Figure 3.5.11. At present there are 12 km of existing sewers, 10 km of existing drainage channels and 8 existing tidal gates. The components of the proposed development project are presented in the following table.

Main Components and Quantities in Kien Anh District

Item	Unit	Quantity	Remarks
Rehabilitation of existing sewer	km	10.0	
Construction of new sewer	km	17.2	20m/ha
Construction of main drainage channel	km	5.0	
Rehabilitation of tidal gate	nos.	7	

3.6.2 Cost Estimates

The cost was estimated using identical unit prices used for Class A area. The unit costs and cost estimates are shown in Table 3.6.1. The preliminary cost estimate is US$10 million and the timeframe for implementation is proposed as 10 years during Phase II.

Construction of the main drainage channel of 5 km length and 12 m width is estimated to involve the loss of about 6 ha of agricultural land and 30 houses. Using the same unit price used for Class A area, the compensation will be US$0.5 million.

3.7 Phased Development and Disbursement Schedule

The total target development area is 5,241 ha for Class A area and 1,362 ha for Kien An District. The total project cost by each area is given in Table 3.7.1. The total cost is US$179 million and the cost of Phase I is US$72.3 million.

The World Bank and FINNIDA Projects are expected to be completed by the year 2004. Phase I of the Class A area is proposed to be implemented between 2004 and 2009. Phase II will start in 2011 and be completed in 2020. The development for Kien An is proposed to start in the year 2011 and be completed in 2020. The annual disbursement of construction and O&M cost is given in Table 3.7.2.

Table 3.5.1 Outline of The Drainage Master Plan Alternatives

	D1	D2	D3	D4
1. Target Area	Central Area, New Urban Area	Central Area, Old City Center, New Urban Area	Central Area, Old City Center, New Urban Area	Central Area, Old City Center, New Urban Area
2. Drainage Target Level	5 year ARI	OCC 2 year ARI Others 5 year ARI	OCC 2 year ARI Others 10 year ARI	OCC 5 year ARI Others 10 year ARI
3. Beneficiary (2020)	425,650	547,102	547,102	547,102
4. Cover Area	4,383 ha	5,240 ha	5,240 ha	5,240 ha
5. Population density	97 persons/ha	104 persons/ha	104 persons/ha	104 persons/ha
5. Project Components	a. Rehabilitation of An Kim Hai Channel (7.7 km) b. Box Sewer (1.5 km) c. Rehabilitation and construction of tidal gates (2 gates) d. Construction of Phuong Luu Lake (24 ha) e. Connecting channel (1 km) f. Construction of new main sewer (42.5 km) g. Rehab of drainage channel (5.5km) h. Construction of pumping stations (3) i. Construction of new tidal gates (3)	a. All components of D1 b. 6 tidal gates c. 5 pumping stations d. New sewer (3.9 km) e. Construction of retarding basins (2) f. Rehabilitation of storage lakes (2) g. Discharge conduit (300 m)	a. All components of D2 b. 2 pumping stations at An Kim Hai Channel c. new sewer (5 km)	a. All components of D3 but designed to serve higher target drainage level
6. Investment Cost	US$ 72.5 million	US$ 90 million	US$ 125 million	US$ 140 million

Table 3.5.2 Assessment of The Drainage Master Plan Alternatives

	D1	D2	D3	D4
1. Target Area	Central Area, New Urban Area	Central Area, Old City Center, New Urban Area	Central Area, Old City Center, New Urban Area	Central Area, Old City Center, New Urban Area
2. Drainage Target Level	5 year ARI	OCC 2 year ARI Others 5 year ARI	OCC 2 year ARI Others 10 year ARI	OCC 5 year ARI Others 10 year ARI
3. Beneficiary (2020)	425,650	547,102	547,102	547,102
4. Cover Area	4,383 ha	5,240 ha	5,240 ha	5,240 ha
5. Urgency	a. Central urban area has inadequate drainage capacity b. Drainage is prerequisite for combine sewerage system	a. Same as D1 b. Old city area faces frequent flooding	a. Same as D2 b. Provides improved drainage target level for central urban area	a. Same as D3 b. Provides improved drainage target level for old city area
6. Investment Cost	US$ 72.5 million	US$ 90 million	US$ 125 million	US$ 140 million
7. Investment cost per beneficiary	US$ 170.33	US$ 164.50	US$ 228.48	US$ 255.89
8. Preliminary Assessment	B	A	C	D

Table 3.5.3 Land Area (km2) and Developed Area Projections for Northeast and Southwest Drainage Basins

No.	Administrative division	Area	Developed Area Ratio			Area Ratio	Area	Developed Area		
		1999	2000	2010	2020		1999	2000	2010	2020
	Ngo Quyen District									
3.01	May To Ward	1.48	74%	74%	74%	17%	0.26	0.188	0.188	0.188
3.03	May Chai Ward	2.32	76%	76%	76%	19%	0.45	0.339	0.339	0.339
3.05	Van My Ward	1.08	88%	90%	90%	100%	1.08	0.951	0.975	0.975
3.07	Lac Vien Ward	0.38	96%	96%	96%	100%	0.38	0.365	0.365	0.366
3.09	Cau Tre Ward	0.45	100%	100%	100%	100%	0.45	0.450	0.450	0.450
3.13	Gia Vien Ward	0.25	100%	100%	100%	100%	0.25	0.251	0.251	0.251
3.15	Cau Dat Ward	0.15	100%	100%	100%	14%	0.02	0.022	0.022	0.022
3.17	Le Loi Ward	0.23	87%	87%	87%	100%	0.23	0.200	0.200	0.200
3.19	Lach Tray Ward	0.67	95%	95%	95%	62%	0.41	0.395	0.395	0.395
3.21	Dang Giang Ward	1.82	73%	85%	96%	25%	0.45	0.329	0.381	0.432
3.23	Dong Khe Ward	1.76	54%	78%	94%	100%	1.76	0.948	1.374	1.650
	Le Chan District									
5.07	Lam Son Ward	0.49	87%	87%	87%	0%	0.00	0.000	0.000	0.000
5.09	An Duong Ward	0.21	100%	100%	100%	0%	0.00	0.000	0.000	0.000
5.11	Tran Nguyen Han Wa	0.27	100%	100%	100%	52%	0.14	0.140	0.140	0.140
5.13	Ho Nam Ward	0.36	93%	93%	93%	100%	0.36	0.335	0.335	0.335
5.15	Trai Cau Ward	0.30	97%	97%	97%	100%	0.30	0.292	0.292	0.292
5.17	Du Hang Ward	0.27	100%	100%	100%	100%	0.27	0.270	0.270	0.270
5.19	Hang Kenh Ward	0.37	100%	100%	100%	100%	0.37	0.370	0.370	0.370
5.21	Dong Hai Ward	0.39	97%	98%	98%	54%	0.21	0.205	0.207	0.207
5.23	Niem Nghia Ward	1.12	93%	93%	93%	0%	0.00	0.000	0.000	0.000
	An Hai Rural District									
6.01	Du Hang Kenh Com.	2.69	54%	88%	88%	29%	0.77	0.417	0.680	0.680
6.02	Vinh Niem Com.	5.63	21%	45%	69%	33%	1.84	0.388	0.827	1.266

Note: Development Area Ratio was estimated using 2020 landuse map prepared by the Team

Table 3.5.4 Land Area (km2) and Developed Area Projections for An Kim Hai Channel Drainage Basin

No.	Administrative division	Area	Developed Area Ratio			Area Ratio	Area	Developed Area		
		1999	2000	2010	2020		1999	2000	2010	2020
	Sub-Basin AKH-1									
5.07	Lam Son Ward	0.49	87%	87%	87%	21%	0.10	0.089	0.089	0.089
5.09	An Duong Ward	0.21	100%	100%	100%	41%	0.09	0.102	0.102	0.102
5.11	Tran Nguyen Han Ward	0.27	100%	100%	100%	48%	0.13	0.102	0.102	0.102
5.23	Niem Nghia Ward	1.12	93%	93%	93%	34%	0.38	0.095	0.095	0.095
	Sub-Basin AKH-2									
6.01	Du Hang Kenh Commune	2.69	54%	88%	88%	46%	1.23	0.055	0.089	0.089
6.03	Dong Hai Ward	0.36	93%	93%	93%	56%	0.20	0.095	0.095	0.095
3.19	Lach Tray Ward	2.32	76%	76%	76%	3%	0.08	0.078	0.078	0.078
5.21	Dong Hai Ward	0.36	93%	93%	93%	5%	0.02	0.095	0.095	0.095
3.25	Dong Quac Bing Ward	0.23	97%	97%	100%	33%	0.08	0.099	0.099	0.102
	Sub-Basin AKH-3									
3.19	Lach Tray Ward	0.15	100%	100%	100%	35%	0.1	0.102	0.102	0.102
3.25	Dong Quac Bing Ward	0.23	97%	97%	100%	59%	0.13	0.099	0.099	0.102
3.21	Dang Giang Ward	1.82	73%	85%	96%	26%	0.48	0.075	0.086	0.098
5.21	Dong Hai Ward	0.39	97%	98%	98%	46%	0.18	0.099	0.100	0.100
6.04	Dang Lam Commune	4.62	65%	79%	87%	6%	0.28	0.066	0.081	0.089
6.05	Dang Hai Commune	2.98	21%	35%	50%	2%	0.07	0.020	0.036	0.051
	Sub-Basin AKH-4									
6.05	Dang Hai Commune	2.98	21%	35%	50%	52%	1.54	0.020	0.036	0.051
6.03	Dong Hai Commune	9.52	51%	58%	65%	16%	1.56	0.051	0.059	0.066
	Sub-Basin AKH-5									
6.03	Dong Hai Commune	9.52	51%	58%	65%	1%	0.13	0.051	0.059	0.066
6.06	Nam Hai Commune	18.96	17%	25%	32%	9%	1.67	0.017	0.025	0.033

Table 3.5.5 Land Area (km2) and Developed Area Projections for Old City Center

No.	Administrative division	Area	Developed Area Ratio			Area Ratio	Area	Developed Area		
		1999	2000	2010	2020		1999	2000	2010	2020
	Hong Bang District									
1.07	Thuong Ly Ward	1.58	92%	96%	100%	100%	1.580	1.458	1.516	1.580
1.09	Trai Chuoi Ward	0.43	84%	84%	84%	100%	0.430	0.361	0.361	0.361
1.11	Ha Ly Ward	1.06	86%	86%	86%	100%	1.060	0.917	0.917	0.917
1.13	Minh Khai Ward	0.67	100%	100%	100%	100%	0.670	0.670	0.670	0.670
1.15	Quang Trung Ward	0.22	100%	100%	100%	100%	0.220	0.220	0.220	0.220
1.17	Hoang Van Thu Ward	0.29	100%	100%	100%	100%	0.290	0.290	0.290	0.290
1.19	Phan Boi Chau Ward	0.16	100%	100%	100%	100%	0.160	0.160	0.160	0.160
1.21	Pham Hong Thai Ward	0.15	91%	91%	91%	100%	0.150	0.136	0.136	0.136
	Ngo Quyen District									
3.01	May To Ward	1.48	74%	74%	74%	10%	0.15	0.110	0.110	0.110
3.03	May Chai Ward	2.32	76%	76%	76%	81%	1.88	1.430	1.430	1.430
3.11	Luong Khanh Thien Ward	0.13	100%	100%	100%	100%	0.13	0.130	0.130	0.130
3.15	Cau Dat Ward	0.15	100%	100%	100%	86%	0.13	0.128	0.128	0.128
	Le Chan District									
5.01	Cat Dai Ward	0.34	94%	94%	94%	100%	0.340	0.318	0.318	0.318
5.03	An Bien Ward	0.18	100%	100%	100%	100%	0.180	0.180	0.180	0.180
5.05	Me Linh Ward	0.12	100%	100%	100%	100%	0.120	0.120	0.120	0.120

Table 3.5.6 Land Area (km2) and Developed Area Projects for New Urban Area

No.	Administrative division	Area	Developed Area Ratio			Area Ratio	Area	Developed Area		
		1999	2000	2010	2020		1999	2000	2010	2020
	Ngo Quyen District									
3.21	Dang Giang Ward	1.82	73%	85%	96%	8%	0.15	0.106	0.124	0.140
3.25	Dong Quoc Binh Ward	0.23	97%	97%	100%	49%	0.11	0.109	0.109	0.113
3.27	Cat Bi Ward	1.29	93%	93%	96%	100%	1.29	1.200	1.200	1.238
	An Hai Rural District									
6.01	Du Hang Kenh Com.	2.69	54%	88%	88%	25%	0.67	0.363	0.592	0.592
6.02	Vinh Niem Com.	5.63	21%	45%	69%	67%	3.77	0.792	1.697	2.603
6.03	Dong Hai Com.	9.52	50%	58%	65%	83%	7.90	3.951	4.583	5.136
6.04	Dang Lam Com.	4.62	65%	79%	87%	94%	4.34	2.823	3.431	3.778
6.05	Dang Hai Com.	2.98	20%	35%	51%	46%	1.37	0.274	0.480	0.699
6.06	Nam Hai Com.	18.96	17%	25%	32%	91%	17.25	2.933	4.313	5.521

Table 3.5.7 Drainage Facilities Cost for Class A Area

Phase	System	Item	unit	quantity	civil works			mec/ele works			Remarks	
					unit cost		cost	unit cost		cost		
(1B Project)	Rehabilitation of Urban center stormwater drainage system	Cleaning and Inspection of Main and Branch Sewers	km	64	15.0	1000 USD	960	-	-	-		
		Cleaning and Inspection of Tertiary Sewers	km	100	18	1000 USD	1,800	-	-	-		
		Rehabilitation of Existing Sewers	km	60	211	1000 USD	12,660	-	-	-		
		Construction of New Sewers	km	7.6	552	1000 USD	4,195	-	-	-		
		Rehabilitation of Northeast Channel	km	3.6	518	1000 USD	1,865	-	-	-		
		Rehabilitation of Southwest Channel	km	2.6	604	1000 USD	1,570	-	-	-		
		Rehabilitation of May Den Tidal Gate	nos.	1	2	1000 USD	2	72	1000 USD	72		
		Rehabilitation of Vinh Niem Tidal Gate	nos.	1	3	1000 USD	3	87	1000 USD	87		
		Rehabilitation of Cat Bi Tidal Gate	nos.	1	1	1000 USD	1	-	-	-		
		Rehabilitation of Tien Nga Lake	ha	2.3	94	1000 USD	216	-	-	-		
		Rehabilitation of Sen Lake	ha	2.0	49	1000 USD	98	-	-	-		
		Rehabilitation of Du Hang and Lam Tuong Lakes	ha	6.6	41	1000 USD	271	-	-	-		
		Sludge/Septage Treatment Facilities	ha	19.0	146	1000 USD	2,774	77	1000 USD	1,463		
		Collector Sewer and Pumping Station: Tien Nga Lake	nos.	1	156	1000 USD	156	78	1000 USD	78		
		Collector Sewer and Pumping Station: Sen Lake	nos.	1	76	1000 USD	76	44	1000 USD	44		
		Sewerage O&M Vehicles and Equipment	nos.	1	-	1000 USD	-	2253	1000 USD	2,253		
	total						26,647		1000 USD	3,997		
(FINNIDA Project)	Upgrading of Urban center stormwater drainage system	Construction of May Den Pumping Station (9m3/s)	nos.	1	110	1000 USD	110	920	1000 USD	920		
		Construction of Vinh Niem Pumping Station (9m3/s)	nos.	1	174	1000 USD	174	950	1000 USD	950		
	total						284			1,870		
(1B Project),(FINNIDA Project) total							26,931			5,867	**total**	**32,798**
Phase I	Rehabilitation of An Kim Hai Channel	Excavation of channel	km	10	274	1000 USD	2,740	-	-	-		
		Revetment works	km	20	323	1000 USD	6,460	-	-	-		
		Maintenance roads	km	20	51	1000 USD	1,020	-	-	-		
		Construction of tidal gates	nos.	3	281	1000 USD	843	520	1000 USD	1560		
		Demolishing of tidal gates	nos.	1	2	1000 USD	2	20	1000 USD	20		
		Misc works	nos.	1	1107	1000 USD	1,107	54	1000 USD	153		
		sub-total					12,172			1,733		
	Construction of Phuong Luu Lake	Excavation of lake	ha	24	183	1000 USD	4,392	-	-	-		
		Revetment works	ha	24	44	1000 USD	1,056	-	-	-		
		Road works	ha	24	19	1000 USD	456	-	-	-		
		Excavation of connection channel	km	0.5	137	1000 USD	69	-	-	-		
		Revetment works, connection channel	km	1.0	285	1000 USD	285	-	-	-		
		Maintenance roads, connection channel	km	1.0	57	1000 USD	57	-	-	-		
		Box culvert, 3 x (3.0 m x 2.0 m)	km	0.5	6338	1000 USD	3,169	-	-	-		
		Gate M/E equipment for box culvert	nos.	1	-	-	-	520	1000 USD	520		
		Misc works	nos.	1	948	1000 USD	948	52	1000 USD	52		
		sub-total					10,432			572		
	Supplementary works	Construction of new sewers	km	10.0	455	1000 USD	4,550	-	-	-		
		Construction of channel road bridges	nos.	15	147	1000 USD	2,205	-	-	-		
		Road Ancillary works	nos.	1	3025	1000 USD	3,025	-	-	-		
		Misc works	nos.	1	978	1000 USD	978	-	-	-		
		sub-total					10,758			-		
	total						33,362			2,305	**total**	**35,667**
Phase II		Rehabilitation of drainage channels	km	5.5	648	1000 USD	3,564	-	-	-		
		Rehabilitation of 2 retarding basin (total 2.5ha)	ha	2.5	260	1000 USD	650	-	-	-		
		Rehabilitation of lake	nos.	3.0	100	1000 USD	300	-	-	-		
		Construction of discharge conduit (3000x2000mm)	km	0.3	4000	1000 USD	1,200	-	-	-		
		Construction of 2 new storage lakes	ha	51.0	246	1000 USD	12,546	-	-	-		
		Construction of tidal gates	nos.	9.0	281	1000 USD	2,529	520	1000 USD	4,680		
		Construction of pumping station (Q=18m3/s)	nos.	1.0	3,600	1000 USD	3,600	8,640	1000 USD	8,640		
		Construction of pumping station (Q= 6m3/s)	nos.	2.0	900	1000 USD	1,800	2,160	1000 USD	4,320		
		Construction of pumping station (Q= 4m3/s)	nos.	2.0	665	1000 USD	1,330	1,596	1000 USD	3,192		
		Construction of pumping station (Q= 3m3/s)	nos.	1.0	500	1000 USD	500	1,200	1000 USD	1,200		
		Construction of pumping station (Q= 1.5m3/s)	nos.	2.0	275	1000 USD	550	660	1000 USD	1,320		
		Construction of new sewers (Central Area)	km	10.0	455	1000 USD	4,550					
		Construction of new sewers(West New Urban Area)	km	17.0	455	1000 USD	7,735	-	-	-		
		Construction of new sewers(East New Urban Area)	km	60.0	455	1000 USD	27,300	-	-	-		
	total						68,154			23,352		
Phase I, Phase II total							101,516			25,657	**total**	**127,173**
Total							128,447			31,524	**Total**	**159,971**

Table 3.5.8 Land Acquisition for Drainage System for Class A Area

Phase	System	Item	unit	quantity	width or area		Land acquisition and conpensation			Phase I			Phase II		
							Land loss		House loss	Land loss		House loss	Land loss		House loss
							Agricaltual	Residential		Agricaltual	Residential		Agricaltual	Residential	
							ha	ha	nos.	ha	ha	nos.	ha	ha	nos.
(FINNIDA Project)	Upgrading of Urban center stormwater drainage system	Construction of May Den Pumping Station(6m3/s)	nos.	1	0.1	ha	0.0	0.1	10	0.0	0.1	10			
		Construction of Vinh Niem Pumping Station(6m3/s)	nos.	1	0.1	ha	0.1	0.0	0	0.1	0.0	0			
	total						0.1	0.1	10	0.1	0.1	10			
Phase I	Rehabilitation of An Kim Hai Channel	Maintenance roads on both sides	km	10.0	10	m	5.0	5.0	1300	5.0	5.0	1300			
		Tidal and Discharge Gates	nos.	2.0	625	m2	0.0	0.3	0	0.0	0.3	0			
	Construction of Phuong Luu Lake	Lake and site area	nos.	1	28	ha	28.0	0.0	0	28.0	0.0	0			
		Connecting channels and maintenance roads	km	0.5	19	m	1.0	0.0	0	1.0	0.0	0			
	total						**34.0**	**5.3**	**1300**	**34.0**	**5.3**	**1300**			
Phase II	New Urban Area	Construction of new storage lakes	nos.	1	51.0	ha	51.0	0.0	102				51.0	0.0	102
		Construction of retarding basin	nos.	1	2.5	ha	0.0	2.5	50				0.0	2.5	50
		Construction of pumping stations	nos.	8	0.1	ha	0.8	0.0	16				0.8	0.0	16
	total						51.8	2.5	168				**51.8**	**2.5**	**168**
Total							**85.9**	**7.9**	**1478**						

Table 3.6.1 Drainage Facilities Cost for Kien An

Phase	Item	unit	quantity	civil works			mec/ele works			Remarks
Phase II	Rehabilitation of existing sewer	km	10.0	80	1000USD/km	800				
	Construction of new sewer	km	17.2	400	1000USD/km	6,896				
	Construction of main drainage channel	km	5.0	400	1000USD/km	2,000				
	Rehabilitation of tidal gate	nos.	7	30	1000USD	210	20	1000USD	140	
	Total					**9,906**			**140**	total **10,046**

Table 3.7.1 Drainage Project Cost by Each Area

(Unit : 1,000US$)

Item		Total (2000-2020)			WB/FINNIDA			Phase I (2000-2010)			Phase II (2010-2020)		
		Civil	Mecanical	sub-total	Civil	Mecanical	sub-total	Civil	Mecanical	sub-total	Civil	Mecanical	sub-total
A. Construction Cost	sub-total 1	**139,458**	**30,559**	**170,017**	**26,931**	**5,867**	**32,798**	**34,467**	**1,200**	**35,667**	**78,060**	**23,492**	**101,552**
1. Urban center		129,552	30,419	159,971	26,931	5,867	32,798	34,467	1,200	35,667	68,154	23,352	91,506
2. Kien An district		9,906	140	10,046	0	0	0	0	0	0	9,906	140	10,046
B. Land Acquisation and Compensation Cost	sub-total 2			**8,958**			**122**			**3,700**			**5,136**
1. Urban center				8,463			122			3,700			4,641
2. Kien An district				495			-			-			495
	Grand total			**178,975**			**32,920**			**39,367**			**106,688**

Table 3.7.2 Annual Disbursement of Construction and Operation & Maintenance Costs for Drainage Projects

Unit : 1,000US$

Cost Component		Area	WB/FINNIDA	Phase I	Phase II	Years																				Total		
				2000-2010	2010-2020	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2000-2010	2010-2020	2000-2020
A. Construction Cost	Civil works	1. Urban center	26 931	34 467	68 154	0	0	8 977	8 977	12 219	5 753	5 952	6 445	8 211	4 862	0	6 815	6 815	6 815	6 815	6 815	6 815	6 815	6 815	6 815	6 815	61 398	68 154	129 552
		2. Kien An district	0	0	9 906	0	0	0	0	0	0	0	0	0	0	0	991	991	991	991	991	991	991	991	991	991	0	9 906	9 906
	Mecanical/Electrical	1. Urban center	5 867	1 200	23 352	0	0	1 956	1 956	1 956	0	300	300	300	300	0	2 335	2 335	2 335	2 335	2 335	2 335	2 335	2 335	2 335	2 335	7 067	23 352	30 419
		2. Kien An district	0	0	140	0	0	0	0	0	0	0	0	0	0	0	0	70	70	0	0	0	0	0	0	0	0	140	140
	sub-total	1. Urban center	32 798	35 667	91 506	0	0	10 933	10 933	14 175	5 753	6 252	6 745	8 511	5 162	0	9 151	9 151	9 151	9 151	9 151	9 151	9 151	9 151	9 151	9 151	68 465	91 506	159 971
		2. Kien An district	0	0	10 046	0	0	0	0	0	0	0	0	0	0	0	991	1 061	1 061	991	991	991	991	991	991	991	0	10 046	10 046
B. Land Acquisation and Compensation Cost		1. Urban center	122	3 700	4 641	0	122	0	1 850	1 850	0	0	0	0	0	1 547	1 547	1 547	0	0	0	0	0	0	0	0	5 369	3 094	8 463
		2. Kien An district	0	0	495	0	0	0	0	0	0	0	0	0	0	165	165	165	0	0	0	0	0	0	0	0	165	330	495
C. Recurring Cost (O & M and related)		1. Urban center				0	0	0	0	91	100	110	120	134	142	142	173	205	237	268	299	330	362	393	424	455	839	3 146	3 984
		2. Kien An district				0	0	0	0	0	0	0	0	0	0	0	0	3	8	13	16	19	22	25	28	31	0	165	165
Sub-total		A. Construction Cost				0	0	10 933	10 933	14 175	5 753	6 252	6 745	8 511	5 162	0	10 141	10 211	10 211	10 141	10 141	10 141	10 141	10 141	10 141	10 141	68,465	101,552	170,017
		B. Land Acquisation and Compensation Cost				0	122	0	1 850	1 850	0	0	0	0	0	1 712	1 712	1 712	0	0	0	0	0	0	0	0	5,534	3,424	8,958
		C. Recurring Cost (O & M and related)				0	0	0	0	91	100	110	120	134	142	142	173	208	245	281	315	349	384	418	452	486	839	3,311	4,149
Total																											74,837	108,287	183,124

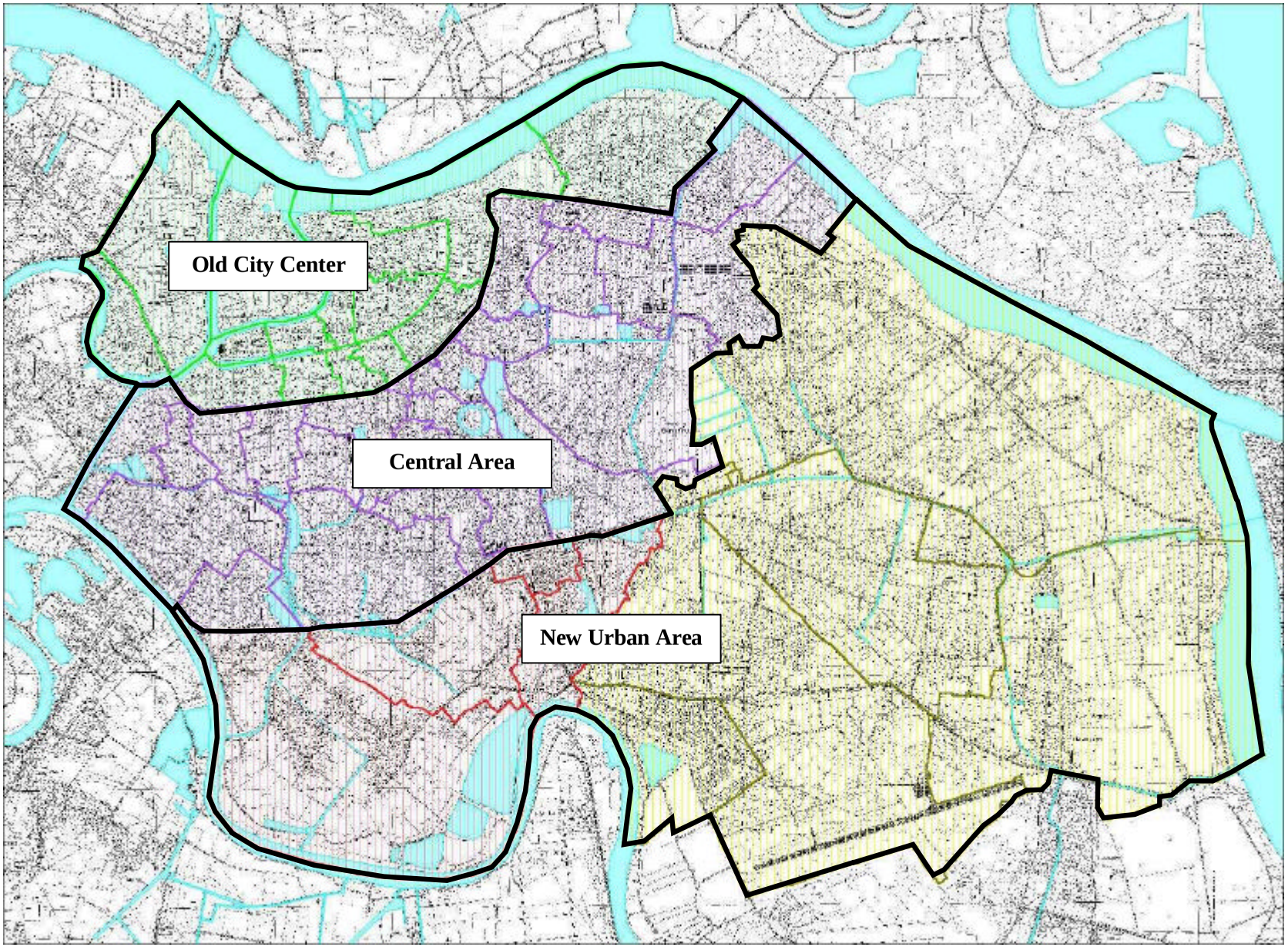


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Figure 3.1.1 Class A Area for Drainage and Sewerage Priority Project

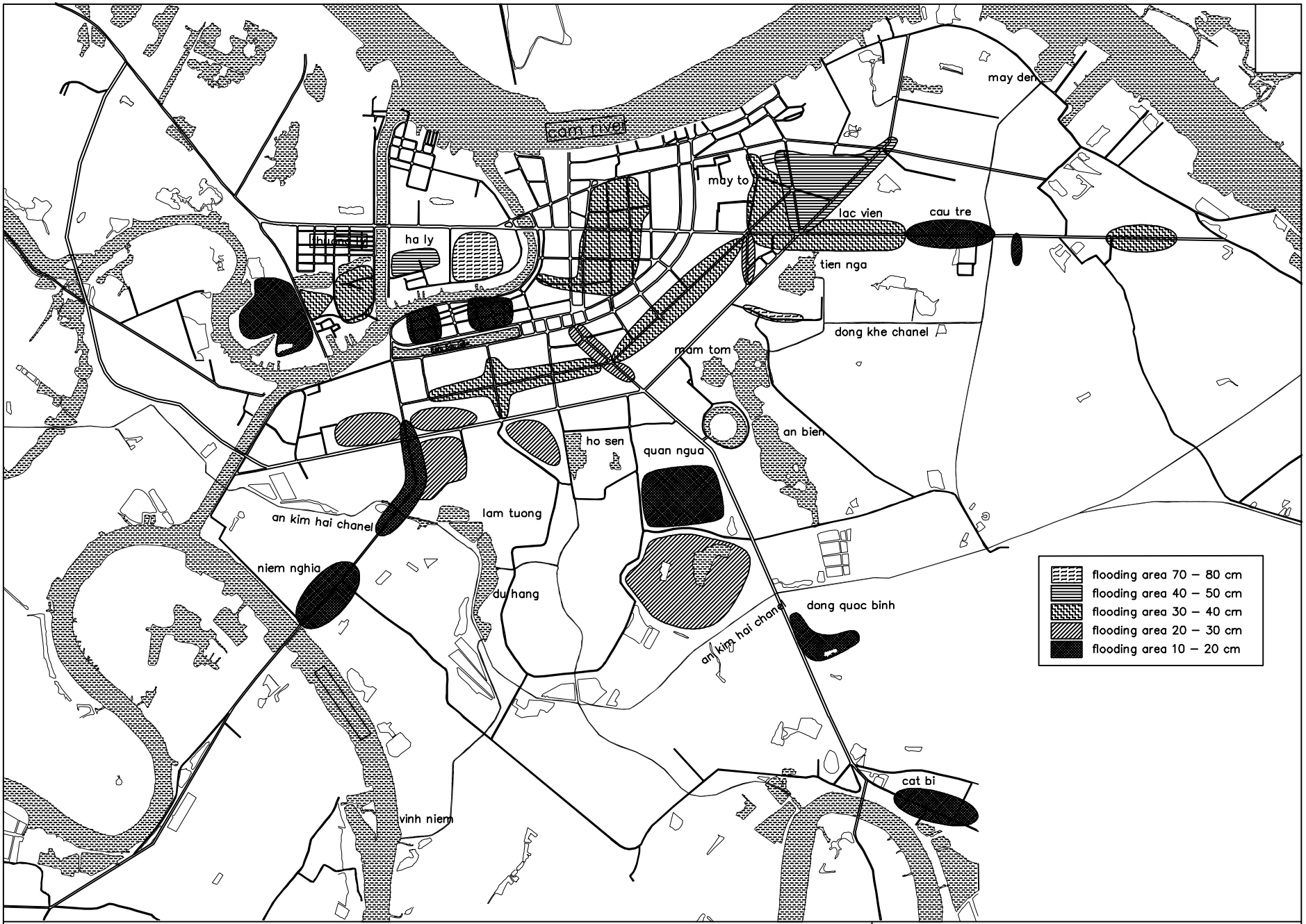

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Figure 3.1.2 Flood Areas in Three Urban Districts Information Reported by SADCo

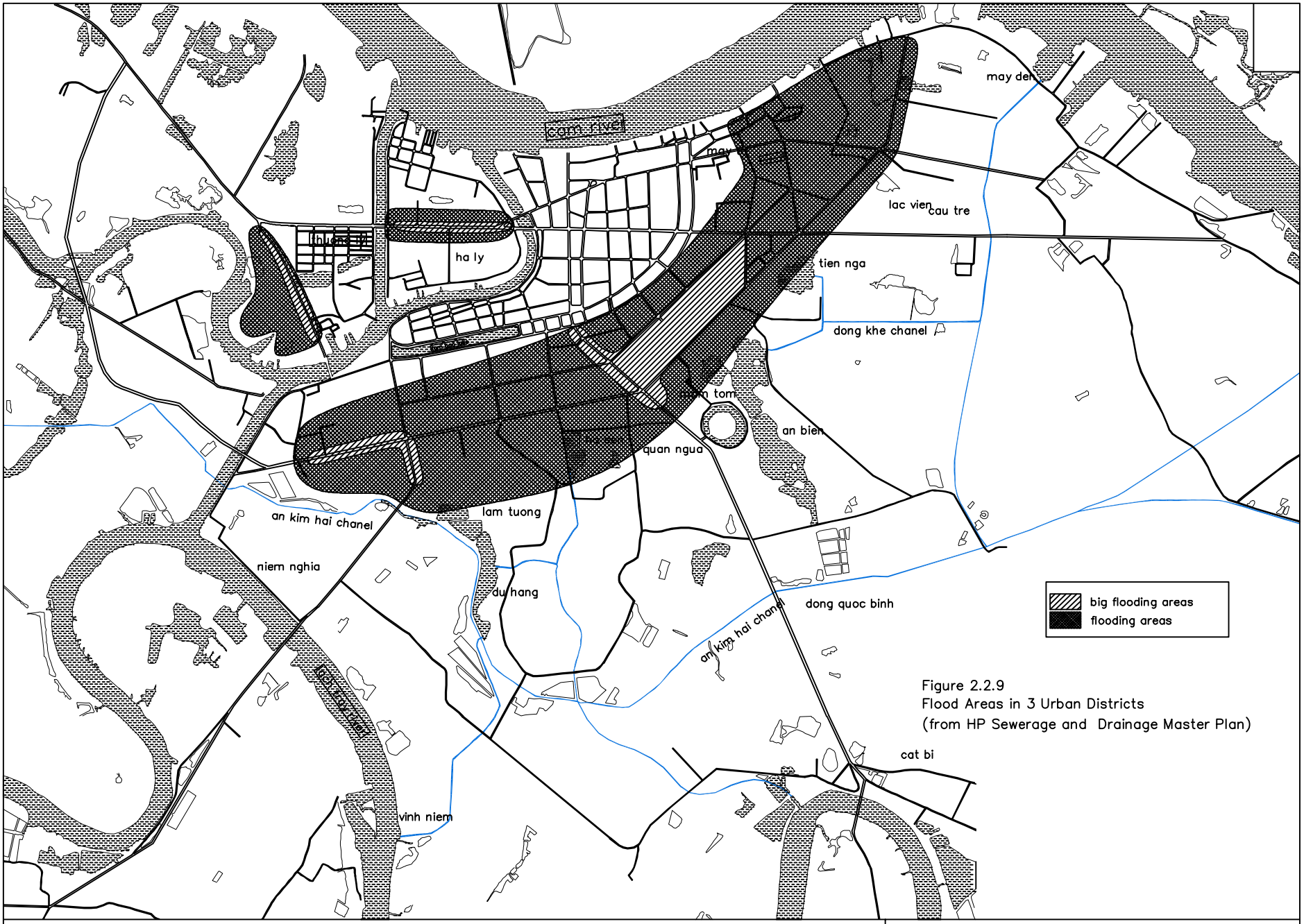

Figure 2.2.9
Flood Areas in 3 Urban Districts
(from HP Sewerage and Drainage Master Plan)

The Study on Sanitation Improvement Plan for Haiphong City in The Socialist Republic of Vietnam	Figure 3.1.3 Flood Areas in Three Urban Districts (HP Sewerage and Drainage MP)
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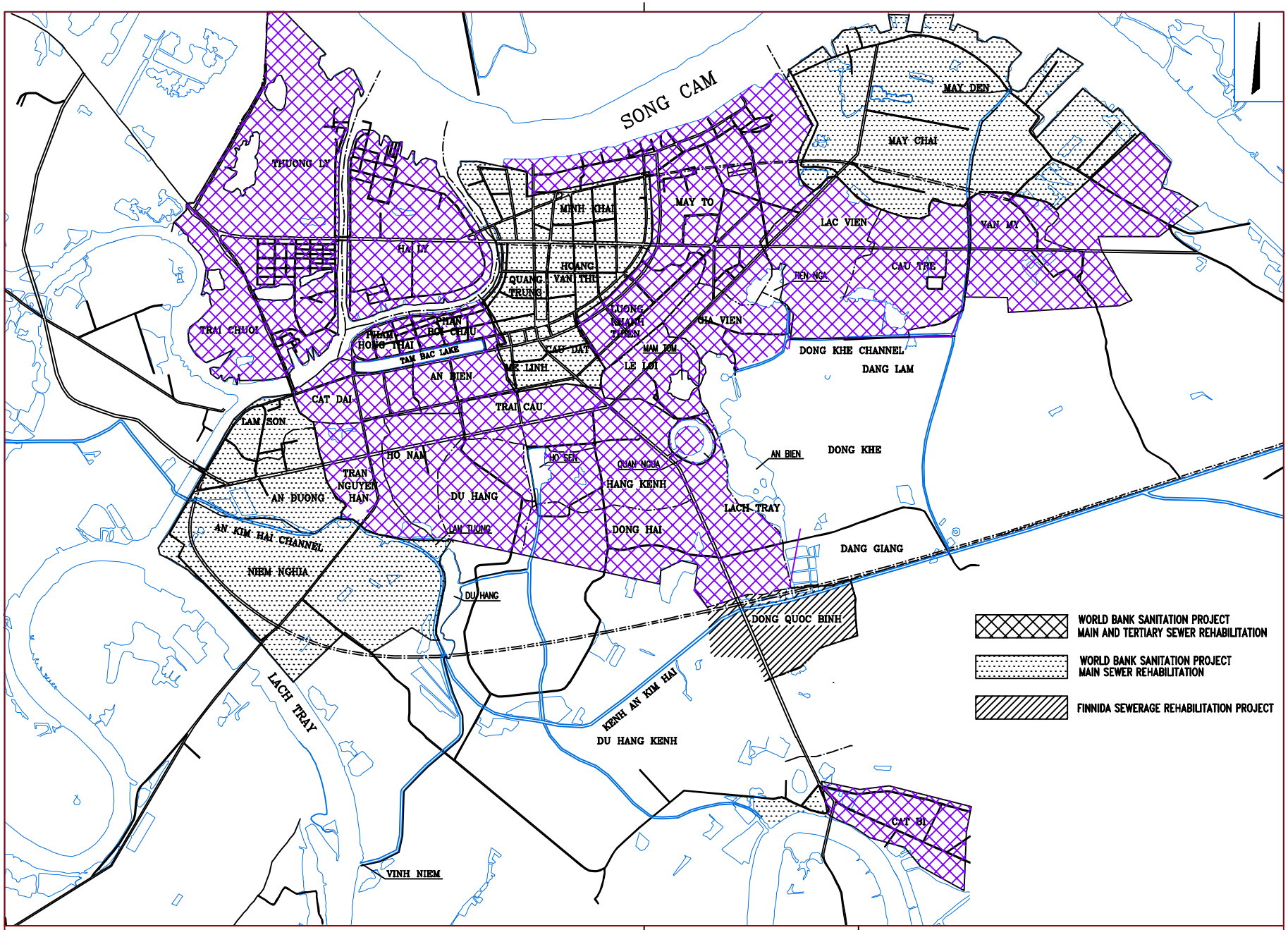

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Figure 3.2.1 World Bank Sanitation Project: Sewer Rehabilitation Areas

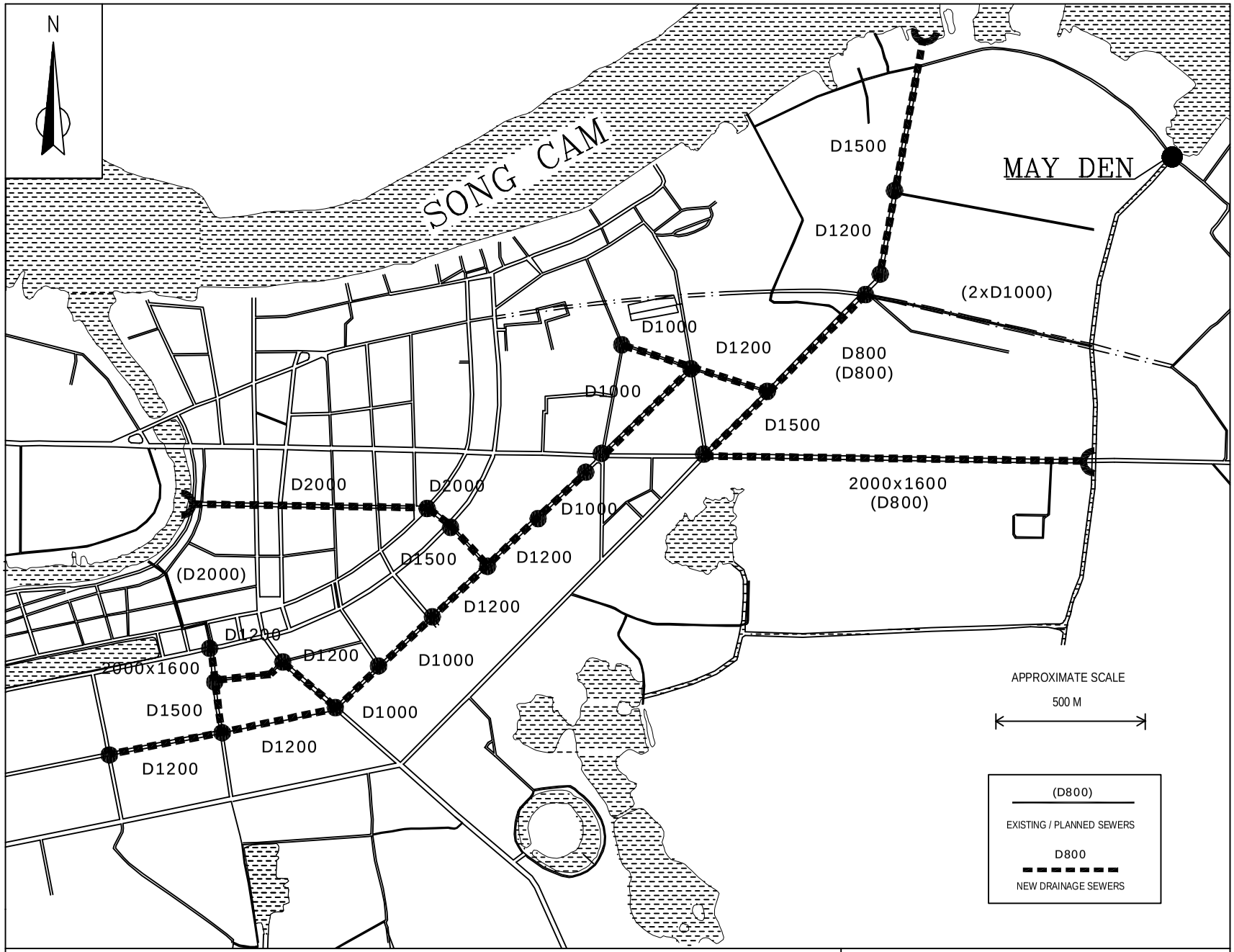

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Figure 3.2.2 World Bank Sanitation Project: New Main Combined Sewers