THE SOCIALIST REPUBLIC OF VIET NAM
PEOPLE'S COMMITTEE OF HAI DUONG PROVINCE

BASIC DESIGN STUDY REPORT ON THE PROJECT FOR EXPANSION OF WATER

FEBRUARY 1999

BASIC DESIGN STUDY REPORT
ON
THE PROJECT
FOR
EXPANSION OF WATER SUPPLY SYSTEM
IN
HAI DUONG CITY
IN
THE SOCIALIST REPUBLIC OF VIET NAM

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JAPAN INTERNATIONAL COOPERATION AGENCY
PACIFIC CONSULTANTS INTERNATIONAL
NIPPON JOGESUIDO SEKKEI CO., LTD.

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PREFACE

In response to the request from the Government of the Socialist Republic of Viet Nam, the Government of Japan decided to conduct a basic design study on the project for expansion of water supply system in Hai Duong City in the Socialist Republic of Viet Nam and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Viet Nam a study team from 30 July to 7 September, 1996 and from 23 August to 16 September,1998.

The team held discussions with the officials concerned of the Government of Viet Nam, and conducted field surveys at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Vietnam in order to discuss a draft basic design, and as this result, the present report was finalized.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Socialist Republic of Viet Nam for their close cooperation extended to the teams.

February 1999

Kimio Fujita
President
Japan International Cooperation Agency

February 1999

Mr. Kimio Fujita

President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit to you the basic design study report on the project for expansion of water supply system in Hai Duong City in the Socialist Republic of Viet Nam.

This study was conducted by Pacific Consultants International and Nippon Jogesuido Sekkei Co., Ltd., under a contract to JICA, during the period from 27 July, 1996 to 27 January, 1998 and from 17 August, 1998 to 10 February, 1999. In conducting the study, we have examined the feasibility and rationale of the project with due consideration to the present situation of Viet Nam and formulated the most appropriate basic design for the project under Japan's grant aid scheme.

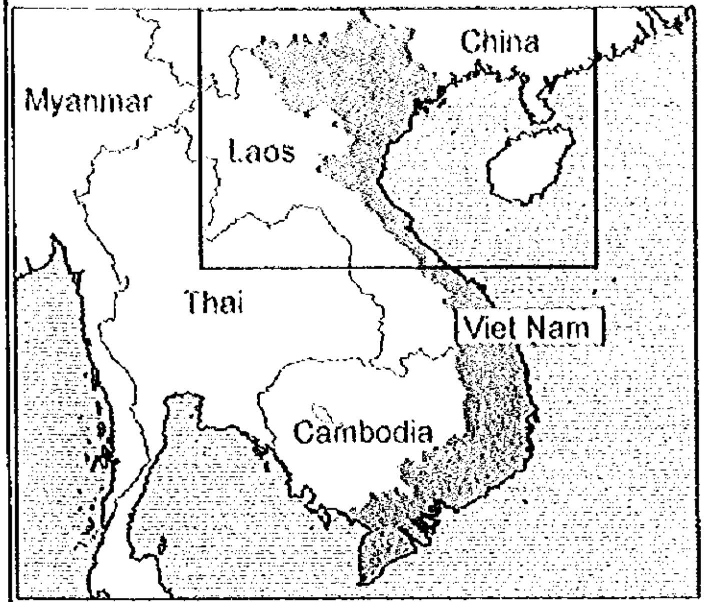
Finally, we hope that this report will contribute to further promotion of the project.

Very truly yours,

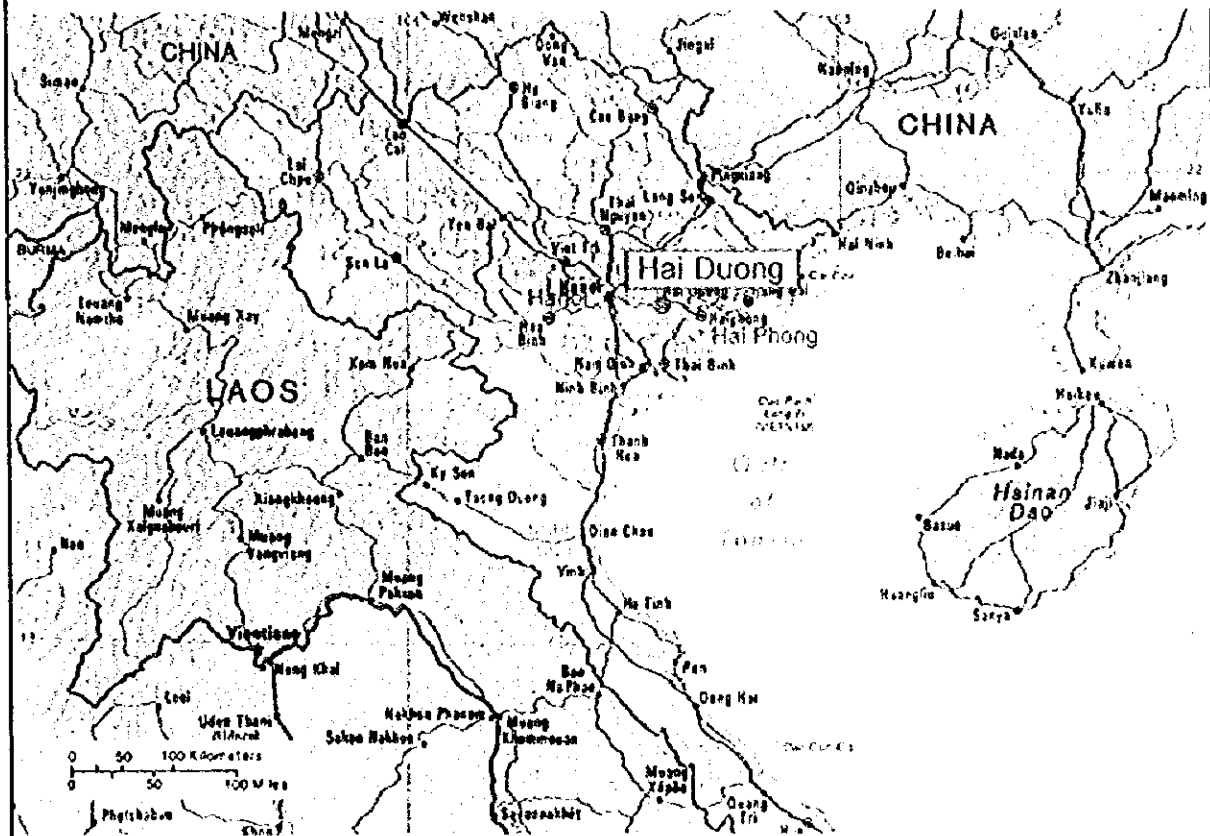
MIYAKOSHI Hiroaki

Project manager,

Basic design study team on
the project for expansion of water supply
in Hai Duong City
in the Socialist Republic of Viet Nam

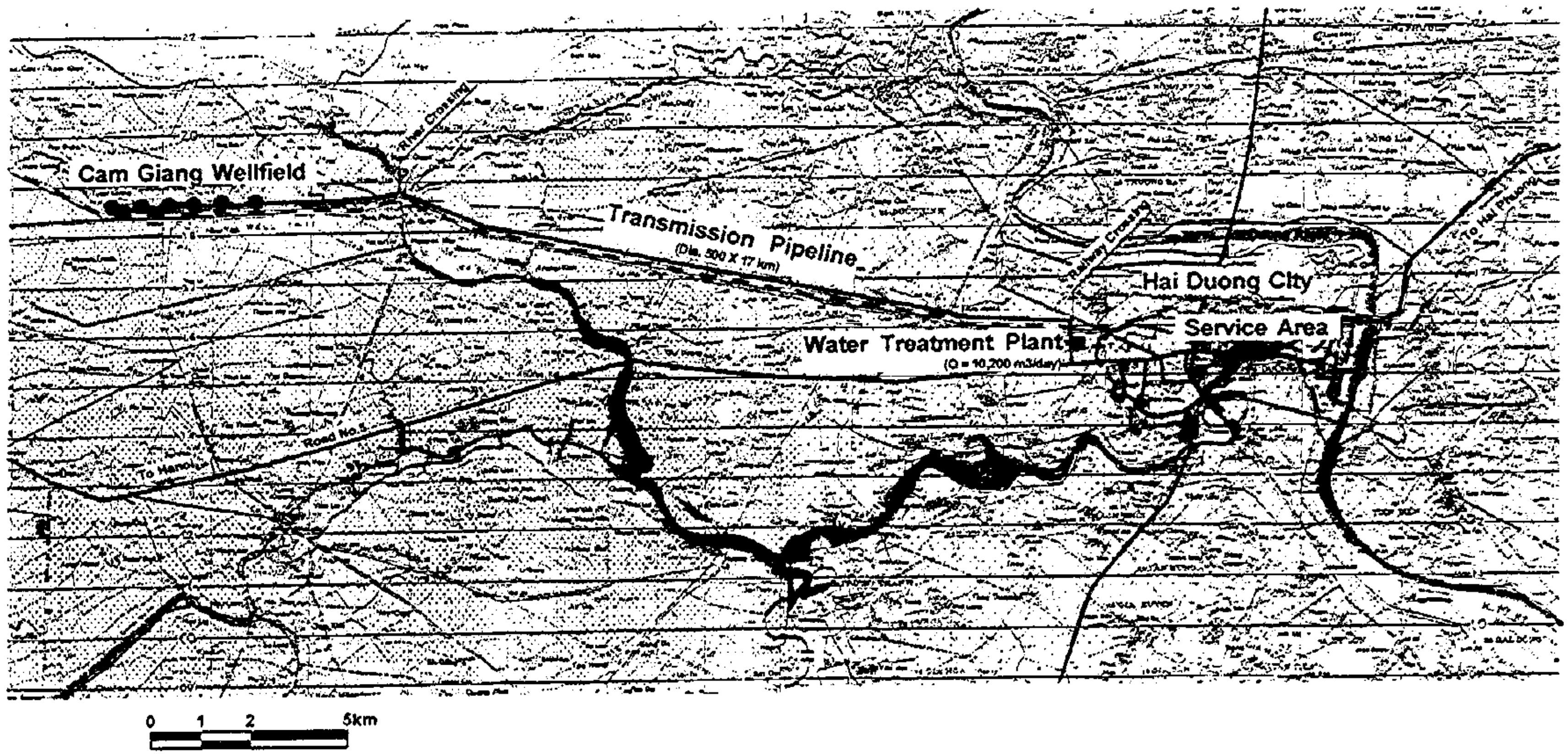


Socialist Republic of Viet Nam

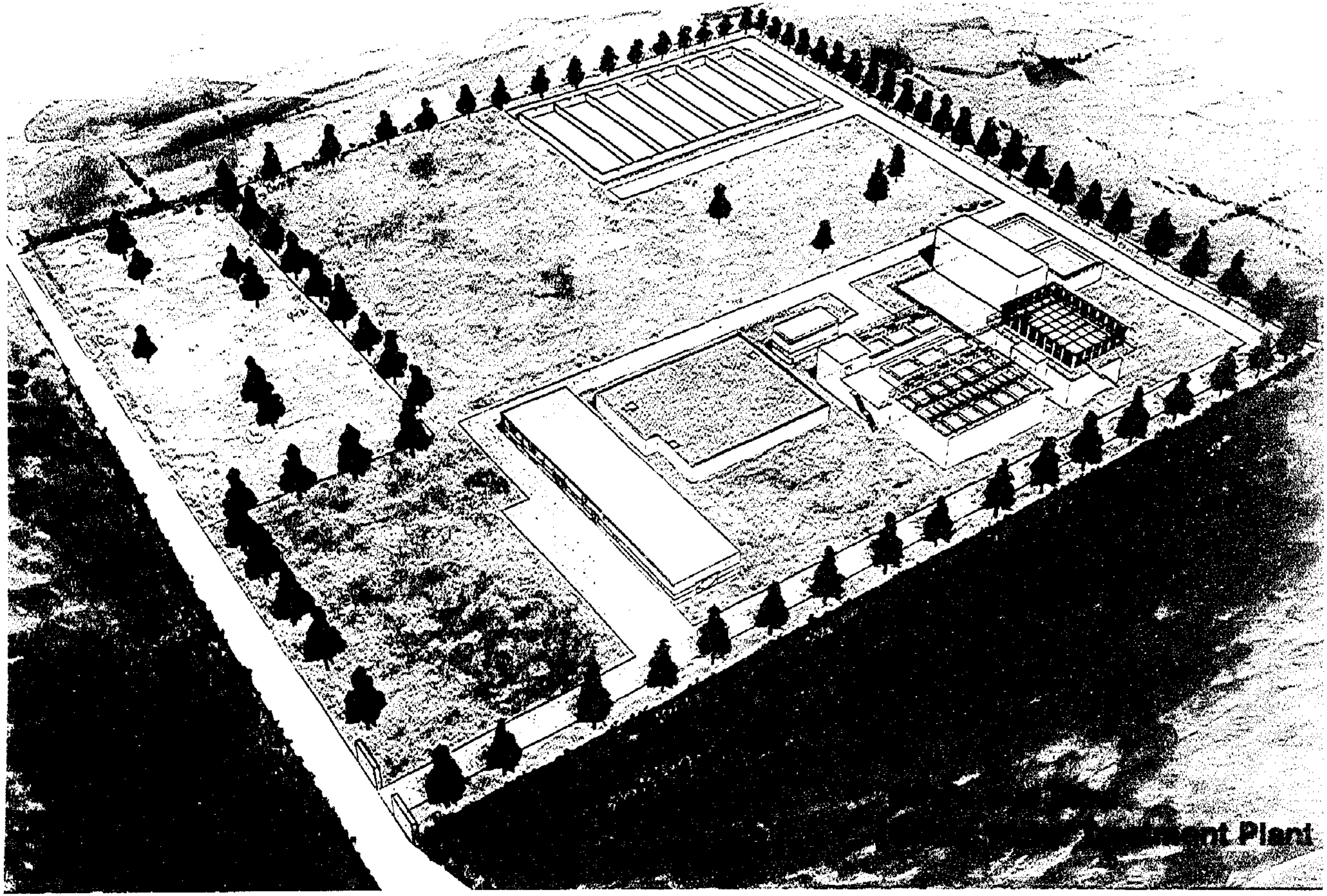


Hai Duong City

Location Map



General Arrangement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ABBREVIATION

ADB	Asian Development Bank
BHN	Basic Human Needs
BIDV	Bank for Investment and Development of Vietnam
DCIP	Ductile Cast Iron Pipe
DOMAH	General Department of Meteorology and Hydrology
EIA	Environmental Impact Assessment
FINNIDA	Finnish International Development Agency
FRP	Fiberglass Reinforced Plastics
IAS	International Accounting Standard
IEE	Initial Environmental Examination
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
K2	Geological Survey of Viet Nam, Hydrogeological Division K No.2
MOC	Ministry of Construction
MOF	Ministry of Finance
MOH	Ministry of Health
MOI	Ministry of Industry
MOLISA	Ministry of Labor, Invalids and Welfare
MOSTE	Ministry of Science, Technology and Environment
MPI	Ministry of Planning and Investment
NWTS	National Water Tariff Policy Study in Vietnam
O&M	Operation and Maintenance
ODA	Official Development Assistance
pH	Hydrogen Ion Exponent
PVC	Polyvinyl Chloride
UNDP	United Nation Development Program
VND	Vietnamese Dong

Currency Exchange Rate

Month of Reference	:	October 1998
Exchange Rate	:	US$ 1 = 136 Yen
	:	US$ 1 = 13,103 VND

CHAPTER 1 BACKGROUND OF THE PROJECT

Chapter 1 Background of the Project

The Socialist Republic of Viet Nam has a land area of 330,000 km^2 and a population of about 75.35 million in 1996, of which urban population stands for 15 million or 28 %.

The social welfare of the country is rather high reflecting the country's policy; 90 % of population has access to medical services and the population per doctor is 2,860, which are kept on rather high level, compared to 81 % and 6,670 of the average value of the developing countries. However, only 48 % of the urban population is served with safe water, which is considered to be at low level, compared to 56 % of the average value of developing countries. Many of the existing facilities are superannuated and the national average of leakage and unaccounted-for water exceeds 50%.

For the purpose of improving the urban water supply, the Ministry of Construction formulated a draft National Development Targets of Urban Water Supply toward the year 2000. Uplifting the service ratio to 65% in provincial cities and 70 % in major cities and reducing the leakage and unaccounted-for water to 25 % are proposed. For more strategic plan of water supply development, 77 cities and towns (including special cities) in the whole country are designated as the priority area ranking from level 1 to 5 according to the population and development urgency. In 1996, a master plan for water supply and sewage of Hai Duong City (then Hai Duong Town) was formulated by the Hai Duong Province (then Hai Hung Province) and approved by the Ministry of Construction.

Presently, the improvement of urban water supply is promptly promoted with aid extended by the international aid agencies and other countries. The Government of Japan has already implemented the grant aid project for the Water Supply System at Gia Lam Area in Ha Noi City and conducted the master plan study for Ha Noi Water Supply System. It was again requested for the grant aid for the water supply projects in 4 cities including Hai Duong. The Japan International Cooperation Agency (hereinafter referred to as JICA) conducted the project identification study in February 1995, and confirmed that the water supply development of Hai Duong City had higher priority, urgency and benefits than the other cities requested by the Government of Viet Nam.

In January 1997, the Hai Hung province, of which capital was Hai Duong town, was disjoined into two provinces: the Hai Duong and the Hun Yen provinces. In September 1997, the administrative category of the Hai Duong town was upgraded to a city. The population of the Hai Duong City was 186,000 in 1996 and the City is considered as a political and economical center of the Province and at the same time a link between the national capital Ha Noi City and Hai Phong port. The Government of Viet Nam designated an extensive economic development zone respectively in the northern, central and southern region of the country. The Project area is located in the northern development triangle zone where the three cities of Ha Noi, Hai Phong and Quang Yen are connected.

Water supply of Hai Duong City is consisted of two facilities. Cam Thuong water treatment plant with source of surface water from Thai Binh river (constructed in 1936, rehabilitated in 1978 and 1997, design capacity 20,000m^3/day) and Hai Tanh water treatment plant with source of ground water (constructed in 1990, design capacity 800m^3/day). However, the average water supply capacity in total is about 14,000 m^3/day due to its superannuation. The leakage at distribution pipes is about 35%. The effective supply capacity is estimated as small as approximately 9,000m^3/day which means about 75% of water demand in the supply area. Therefore, the water supply for the residents is restricted to every other day.

As raw water contains high iron concentration, iron, stench (metallic taste) and color (red-brown) remain in the treated water at Hai Tanh water treatment plant. Although the water quality is not harmful to health, there are many complaints made by the residents. Another problem with Cam Thuong water treatment plant is extremely high turbidity of raw water and large seasonal fluctuation of water level at the river intake. The huge expense of the provincial government and time are involved in dredging sediments in and around the intake facility after flooding, particularly in a year of many typhoons.

Under the present situation and in order to uplift the service ratio of Hai Duong City to the National Target by expanding water supply facility, Hai Hung Province (at that time) formulated a master plan for water supply and sewage in 1996. The target of service ratio is determined as 56% in 2000 and 85% in 2010 by promoting the water resource development and the expansion of water treatment plants and distribution pipes.

Based on the background and the master plan mentioned above, the Government of Viet Nam requested to the Government of Japan for the grant aid for expansion of water supply system in Hai Duong City.

CHAPTER 2 CONTENTS OF THE PROJECT

Chapter 2 Contents of the Project

2.1 Objectives of the Project

The Project is targeted to supply safe water from newly developed ground water source and to mitigate acute shortage of water supply in the Central Area, i.e., the political and economic center of Hai Duong City in compliance with the City's Master Plan. The Project is to implement an urgent water supply scheme for the area of the highest priority, the east and the west sections of the Central Area. By the Project, the rate of population served will be improved from 32 to 50%.

2.2 Basic Concept of the Project

In the initial plan, water supply plan was formulated to expand the water service area where piped water is not supplied and to improve water supply conditions of a part of the existing service area. As for unit water demand it was proposed to be 135 l/c/d for domestic use which was formulated in the City's Master Plan. However, after consultation with the Ministry of Foreign Affairs, Japan, the project scale was proposed to be scaled down in view of project scale as a Japan's Grant Aid system. After discussions with the Government of Viet Nam, the projected service area as well as population served have been scaled down. Unit water demand has been reviewed as well to 100 l/c/d in the final plan. This report describes about both of initial plan and final plan.

2.2.1 Proposed Service Area

The Central Area of the Hai Duong City comprises nine (9) wards (urbanized area consisting of wards I to X except VII) and two (2) communes (semi-urbanized area consisting of commune 6 and 7). According to the Hai Duong City Master Plan, 1995 by the Planning and Investment Department of the Hai Hung People's Committee, land readjustment works and improvement works of streets and road networks will be completed by 2000 in the urbanized Central Area, and targeted at 2005 in the semi-urbanized areas.

In the service area by the existing treatment facility, rapid growth of population without upgrading the water treatment capacity has resulted in the serious shortage of supply compared to the increased demand. In these areas, the water supply has been made every other day to one of the areas divided into two. Even now, when the actual supply of the existing Cam Thuong Water Treatment Plant was recovered to 9,000 m^3/day by a rehabilitation project under the commodity loan from OECF, the situation did not improve significantly.

The Project is to implement the development of new water source, the construction of a water treatment plant and the water supply service for non-service area at present in the Central Area of the highest priority. A part of the existing service area where water is distributed by superannuated pipes will be included within the Project service area after the pipe renewal carried out by the Project. Then, the water shortage in the existing service area will be mitigated.

In the initial plan, the existing service area is divide into two, "service area a" where is assumed to be served by the existing system and "service area b" where water is to be supplied by the new treatment plant. In addition to the areas, "service area c" was formulated where the no piped water is supplied now and water will be supplied by the new plant. These service areas proposed in the initial plan are described below:

- Service Area "a": Parts of the existing service area of the Cam Thuong water supply system, which are assumed to be served by the same system even after 2000. After the Project, the water shortage in this area will be mitigated since a part of the service area "b" is to cease to receive the supply from Cam Thuong.
- Service Area "b": Parts of the existing service area of the Cam Thuong water supply system. After the Project, the new treatment plant will supply to parts of this area.
- Service Area "c": Non-service area at present. This area is to be served by the Project, except partial areas located along eastern and western periphery of the City.

The final plan, in view of project scale as a Japan's Grant Aid system, has been formulated by reviewing the service area and population served of the initial plan after discussions with the Government of Viet Nam. The proposed service area of the final plan is shown in Fig. 2.1b.

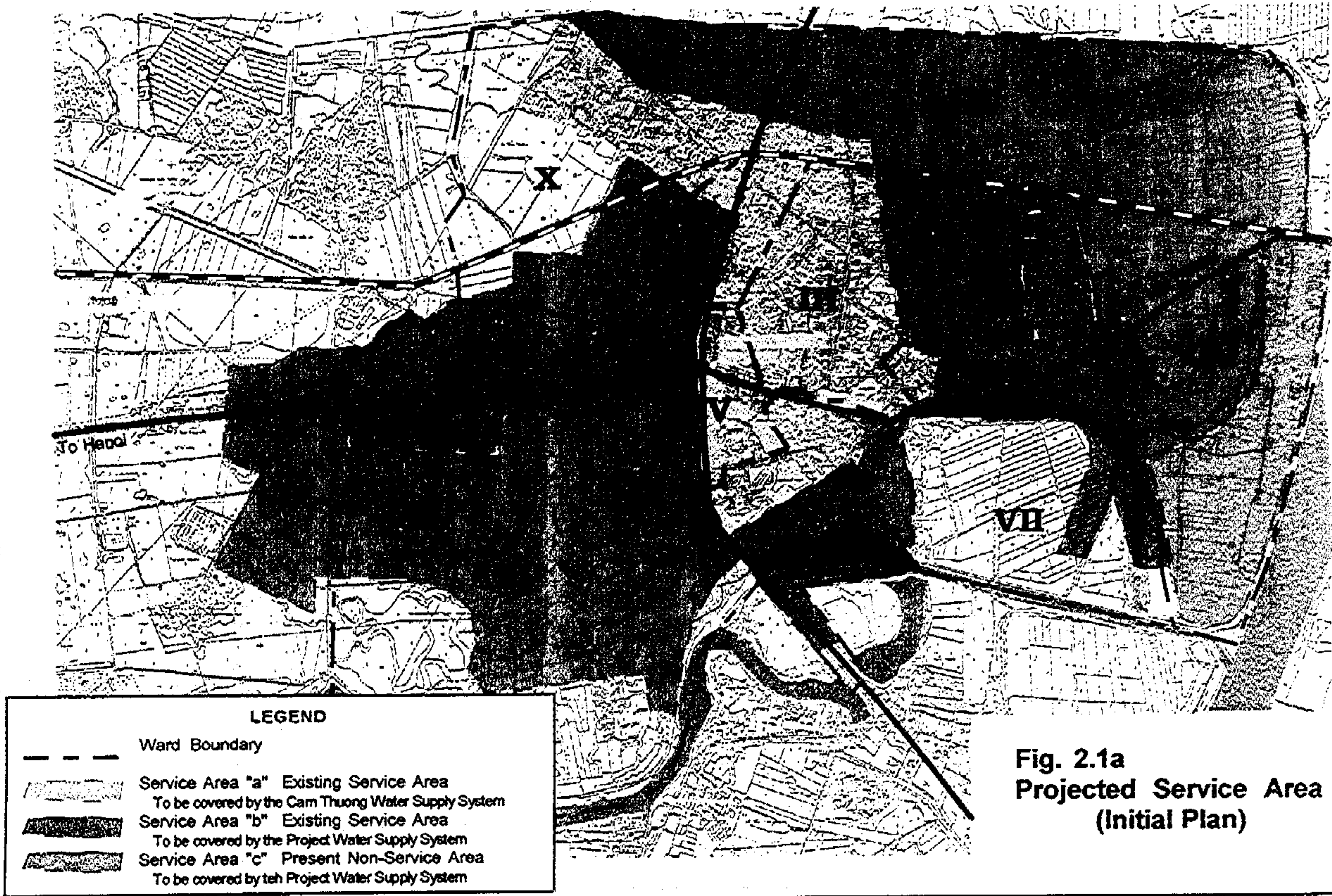

Fig. 2.1a
Projected Service Area
(Initial Plan)

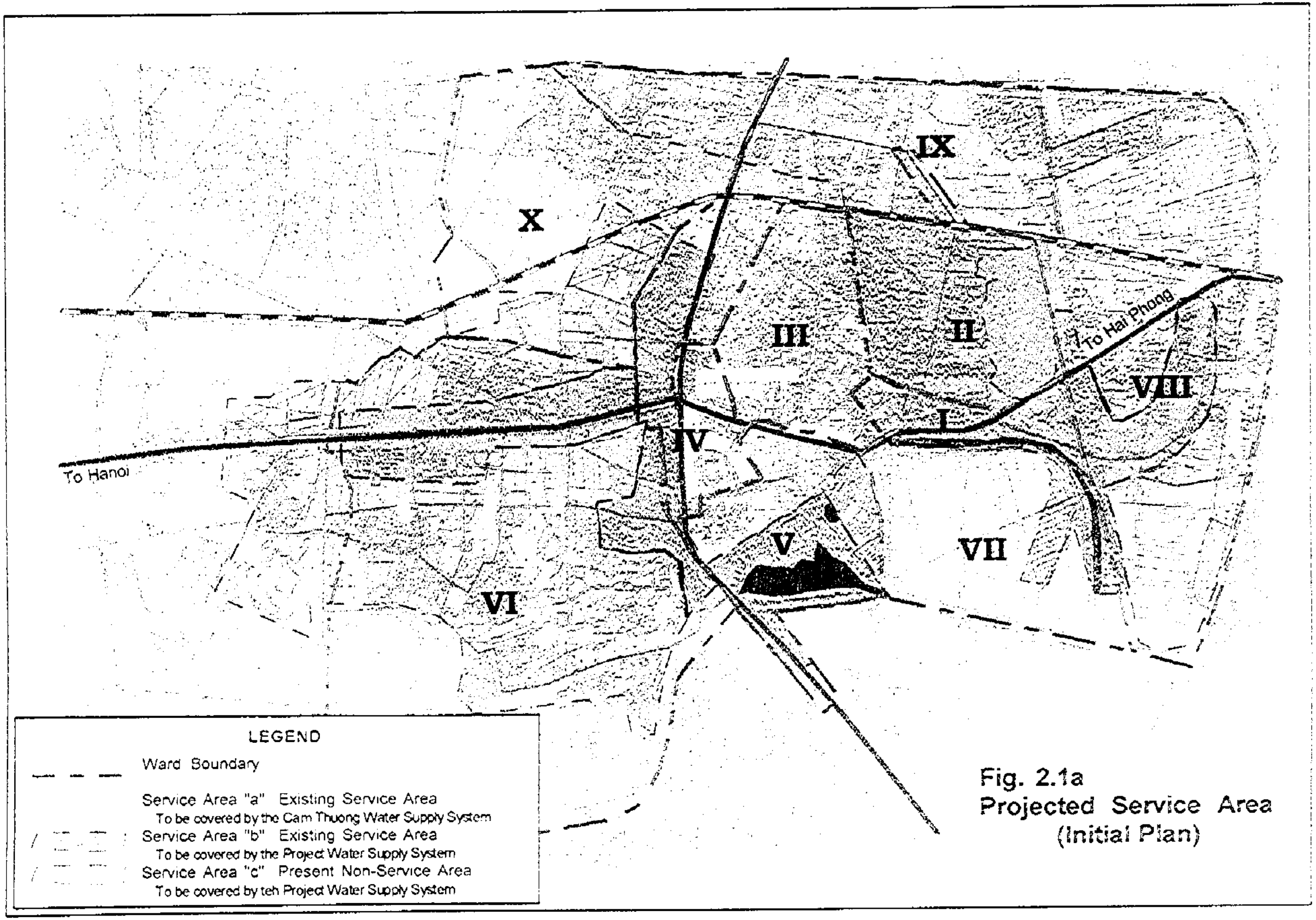

Fig. 2.1a
Projected Service Area
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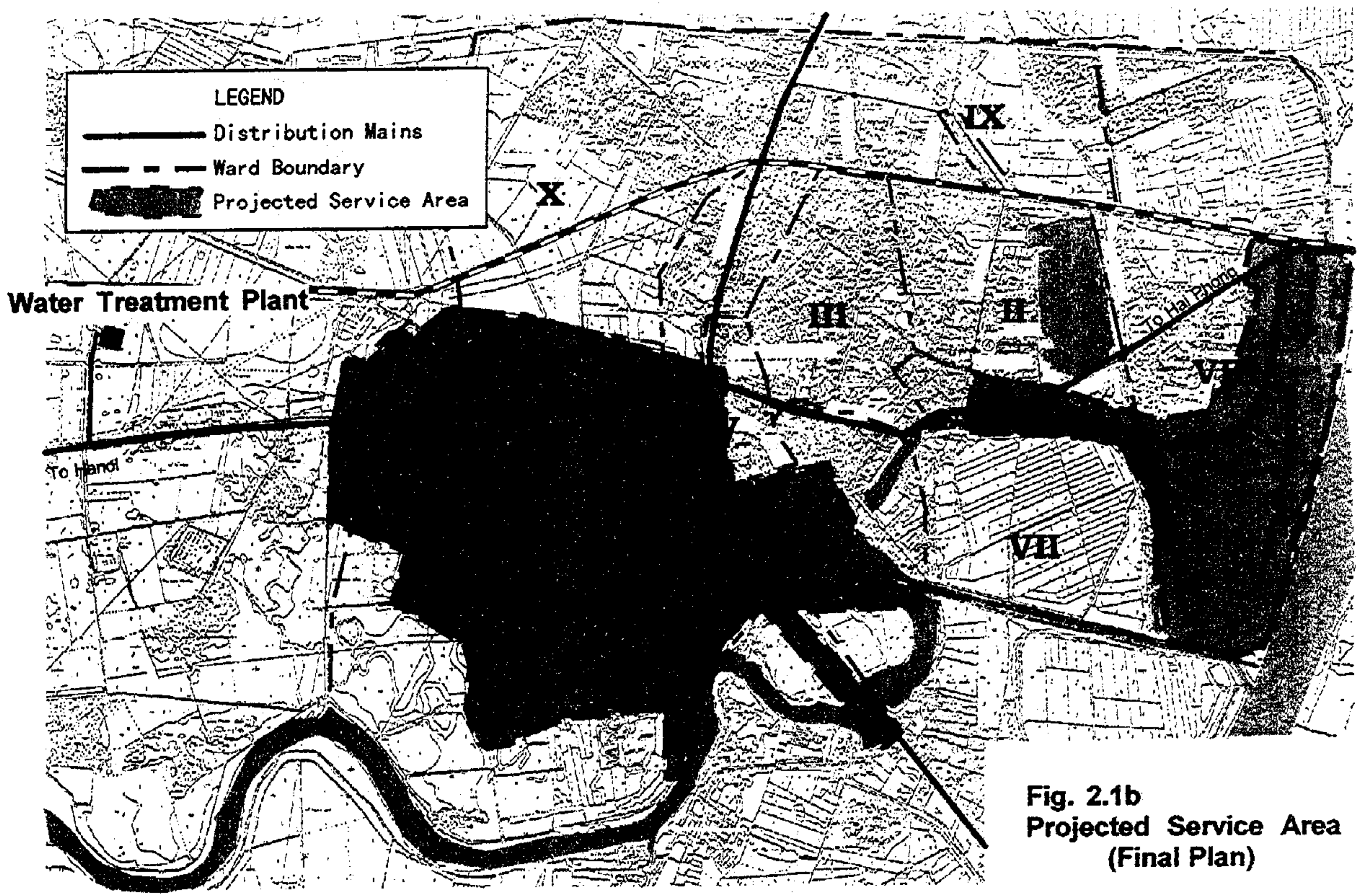


Fig. 2.1b
Projected Service Area
(Final Plan)

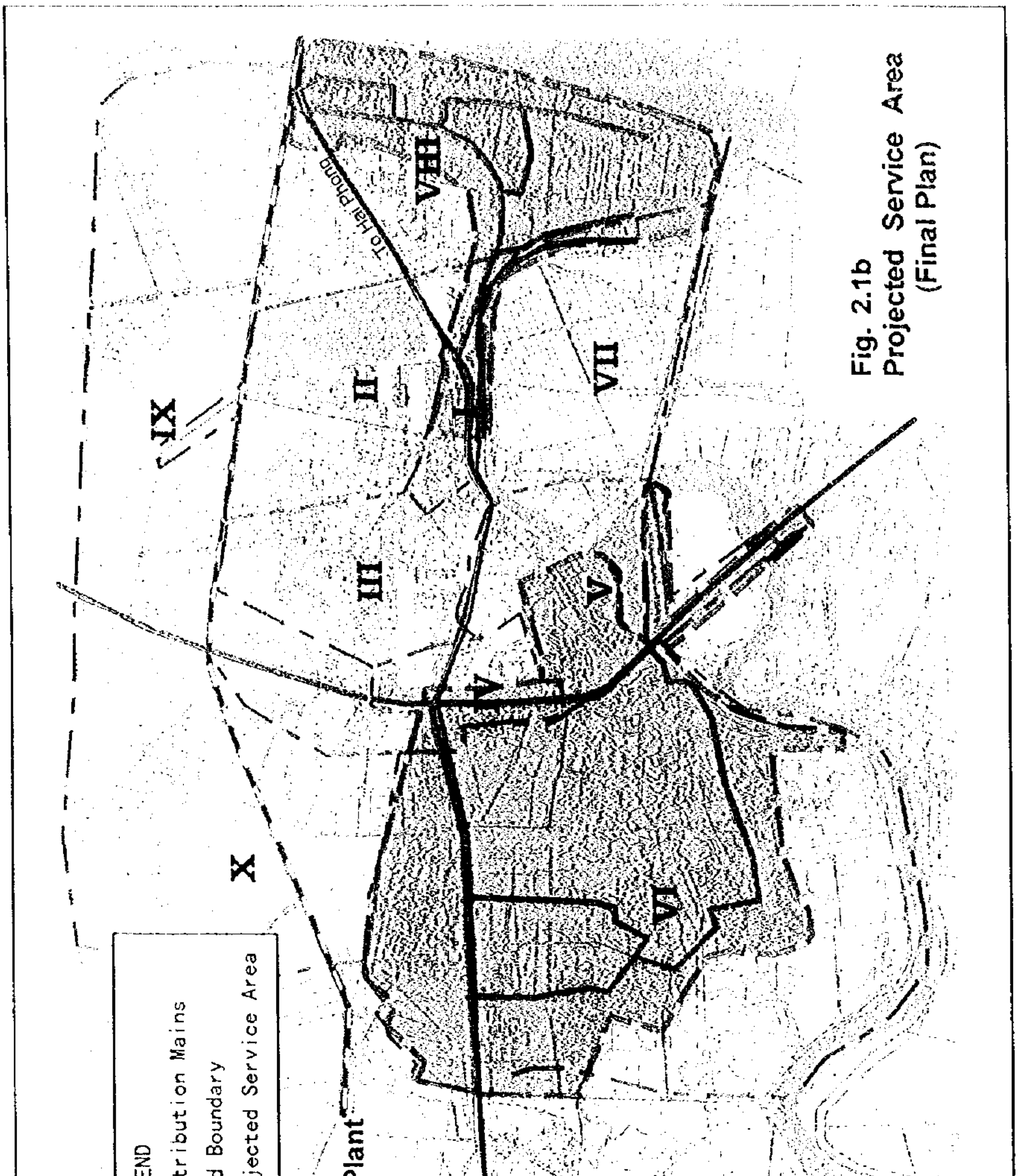


Fig. 2.1b
Projected Service Area
(Final Plan)

2.2.2 Population Served

The Central Area is the most densely populated area where acute shortage of water is prevailing. Improvement of water supply in the Area will bring about higher beneficial effects and thus help to develop the Provincial economy by supporting the socio-economic function of the Capital City of Hai Duong Province.

Taking into consideration of the water supply capacity and the water demand in the Central Area, the proposed water supply plan is projected as shown in the following tables: Table 2.1a shows the initial plan made in the first year study; and Table 2.1b shows the final plan after reduction of project scale in the second year study.

It is assumed that the existing treatment plant at Hai Thang will cease to operate.

Table 2.1a Initial Water Supply Plan (the First Year Study)

Year			1996	2000
Population (Water Demand)	Central Area		135,756 ($25,323m^3$)	156,600 ($25,946m^3$)
	Entire City		185,584 ($29,695m^3$)	208,908 ($37,050m^3$)
Served Population (Water Supply)	Central Area	Existing	59,000 ($9,000m^3$)*	49,090 ($9,000m^3$)*
		Planned	–	**69,350 ($16,690m^3$)***
		Total	59,000 ($9,000m^3$)*	118,440 ($25,690m^3$)*
	Entire City		59,000 ($9,000m^3$)*	118,440 ($25,690m^3$)*
Service Ratio (Population based)	Central Area		43.5%	75.6%
	Entire City		31.8%	56.7%

Table 2.1b Final Water Supply Plan (the Second Year Study)

Year			1996	2000
Population (Water Demand)	Central Area		135,756 ($25,323m^3$)	156,600 ($25,946m^3$)
	Entire City		185,584 ($29,695m^3$)	208,908 ($37,050m^3$)
Served Population (Water Supply)	Central Area	Existing	59,000 ($9,000m^3$)*	57,940 ($9,000m^3$)*
		Planned	–	**46,000 ($8,200m^3$)***
		Total	59,000 ($9,000m^3$)*	103,940 ($17,200m^3$)*
	Entire City		59,000 ($9,000m^3$)*	103,940 ($17,200m^3$)*
Service Ratio (Population based)	Central Area		43.5%	66.4%
	Entire City		31.8%	50.0%

Note: Volume of demand as daily average. Ref. Appendix 5
Volume of supply (*) as daily maximum.

According to the Hai Duong City Master Plan, land readjustment works and improvement works of streets and road networks will be completed by 2000 in the urbanized Central Area, and targeted at 2005 in the semi-urbanized areas.

An urgent improvement scheme targeted to enhance the urban infrastructure is therefore proposed to upgrade water supply in the urbanized area where the urban redevelopment is completed by the year 2000. Follow-on extension works are expected in the semi-urbanized areas corresponding to degree of urban development.

2.2.3 Proposed Water Supply Capacity

(1) Unit Water Demand

In reference to those in the Hai Duong City Master Plan, the unit water demands applicable to the Project are formulated as shown in table 2.2. Units in column "Final Plan" shall be applied in the Project.

Table 2.2 Comparison Table of Unit Water Demand for 2000

	Master Plan	Initial Plan (1st Year Study)	Final Plan (2nd Year Study)
Rate of Population Served in Urbanized Area	75 %	90 %	79 %
Domestic Use	40~180 l/c/d	135 l/c/d	100 l/c/d
Commercial Use (Unit water demand)	15 % 18 l/c/d	15 % 20.25 l/c/d	15 % 15.0 l/c/d
Industrial Use (Unit water demand)	30 % 36 l/c/d	m^3/ha 25 m^3/ha	12 % 12.0 l/c/d
Cleaning (Unit water demand)	10 % 12 l/c/d	10 % 13.5 l/c/d	10 % 10.0 l/c/d
Physical Loss, etc.	25 %	15 % (Current: 35%)	15 %
In-Plant Utility Water	6 %	6 %	5 %
Daily Maximum Factor	1.3	1.3	1.3
Peak Hourly Factor		1.35	1.35

Note: More details are shown in Appendix 5.

(2) Water Demand Forecast

Population forecast was made for each ward and commune by the Hai Duong City Master Plan. Based on the past and present movement of population, the rate of population increase is estimated by considering the situation of population distribution and land utilization. The rate of population increase before 2000 in the urbanized area is estimated as average 3.8 % considering the migration of rural population to the City. The water demand forecast is summarized in Table 2.3 by using the unit water demand and the population forecast.

Table 2.3 Water Demand of Hai Duong

(Average daily water demand m^3/d)

	Year 1996		Year 2000	
	Persons	m^3/d	Persons	m^3/d
Northern area				
Urban area	-	-	-	-
Semi-urban area	27,793	1,567	29,324	4,911
Subtotal	27,793	1,567	29,324	4,911
Central area				
Urban area	64,203	13,310	131,600	21,739
Semi-urban area	71,553	12,012	25,000	4,208
Subtotal	135,756	25,323	156,600	25,946
Southern area				
Urban area			8,400	1,414
Semi-urban area	22,035	2,806	14,548	2,029
Subtotal	22,035	2,806	22,984	3,446
Grand total	185,584	29,695	208,908	37,050

(Note) Northern area : Commune 1-3
Central area : Ward I－VI, VII－X、 Commune 6,7
Southern area : Ward VII, Commune 4,5

(3) Planned Water Supply Capacity

Water demand of the urbanized area in the Central Area at 2000 is 21,739 m^3/day (ref. Appendix 5). On the other hand, the production capacity of the existing water treatment plant was recovered to 9,000 m^3/day after the rehabilitation in 1997 under the OECF loan. It is therefore required to augment a 12,739 m^3/day capacity at daily average for meeting the demand in the urbanized Central Area.

The initial plan in the first year basic design study entailed 21,000 m^3/day as the maximum production capacity of the new treatment capacity, by assuming the daily maximum factor of 30 %, leakage factor of 15 % and the in-plant utility water of 6 %.

The final plan applied revised factors in Table 2.1b as well as Table 2.2, and reduction of the project scale to that of 10,200 m^3/day was projected.

Table 2.4 shows water demand of the proposed service area.

Table 2.4 Water Demand of the Proposed Service Area (2000)

		Initial Plan 1stYearStudy	Final Plan 2ndYearStudy	
A	Population Served (persons)	69,350	46,000	
B1	Domestic Water (m^3/day)	9,363	4,600	Ax135 l/c/d, 100 l/c/d
B2	Commercial Use (m^3/day)	1,405	690	B1x15%
B3	Industrial (m^3/day)	1,109	560	B1x12%
B4	Cleaning (m^3/day)	936	460	B1x10%
B	Sub-Total	12,813	6,310	B1+B2+B3+B4
C	Leakage of Pipeline (m^3/day)	2,261	1,114	B / (1-0.15)
D	Daily Average Supply (m^3/day)	15,074	7,424	B+C
E	Daily Maximum Supply (m^3/day)	19,595	9,651	Dx1.3
F	Daily Maximum Treatment (m^3/day)	21,000	10,200	E x (1+0.06), (1+0.05)

The required maximum production capacity of new water treatment plant is calculated, by adding the in-plant utility water, to 21,000 m^3/day in the initial plan and to 10,200 m^3/day in the final plan.

2.2.4 Suggestions for Water Supply Development after the Project

In order to supplement the Project, it is suggested that the applied unit demand for domestic use be restored to 135 l/c/d, i.e., the level of the initial plan, and the maximum production capacity be augmented to 13,800m^3/day by expanding the water intake and treatment facility of the Project.

2.3 Basic Design

2.3.1 Design Concept

(1) Considerations for Natural Conditions

1) Geology and Hydrogeology

Based on the results of the pumping test conducted by JICA, Ha Noi layer was proved to be a suitable source of groundwater development, for its permeability, storage capacity, mass, continuity and depth of the aquifer. Taking into consideration chloride concentration in the raw water (standards: 250 mg/l or less), well drilling sites were selected in Cam Giang area located some 20 km west of the City center. (Details are shown in Fig. 3.1 of Appendix 6.)

The results of the soil investigation at sites for a river crossing of transmission pipeline and for the treatment facility indicated that the soft clay formation and loose sand are prevalent to the depth of 30 m. Pile foundation is required to support heavy structure.

2) Other Natural Conditions

The annual rainfall is approximately 1,200 mm, 70 % of which intensifies in the monsoon season from May to October. There are strong rains and typhoons affecting the road conditions. Care should be taken to construction scheduling of intake facility (well field) and transmission pipeline. Flood occurs frequently. Ground level shall be raised for well pump stations and water treatment plant. Temperature is fairly hot with high humidity. Heat concentration occurs under direct sunshine. Care should be taken in selecting material for pipe, etc. to avoid deformation during storage. No remarkable earthquake has occurred in the past so that it is not considered in structure design.

(2) Considerations for Social Conditions

Acquisition and lease of land, approval for well drilling and permits for pipe-laying across rivers, railroads and roads require various administrative procedures. Time required for such procedures should be taken into account in construction schedule.

Procedures required in water supply projects are shown in Table 2.5.

Table 2.5 Formalities Relating to Water Supply Project

Items	Formalities
Design	Approval by Ministry of Construction
Road Crossing Works	Permission of Ministry of Transportation
River Crossing Works	Permission of Ministry of Agricultural and Rural Development
Water Quality	Inspection by Ministry of Health
Drilling of Wells	Approval and Permission of Ministry of Industry

(3) General Conditions for Construction Works (General Contractors and Equipment/Materials)

Most of construction and consulting companies belong to the government organizations in Viet Nam. Number of workers in the construction industries is limited and that with experience are lesser. Due to prevalence of brick and wood structures in the country, skilled plasterers and carpenters are available but skilled concrete workers and plumbers are rare. There are a groundwater development company affiliated to Ministry of Industry and other well drilling companies with ample experience, and their technical capacities are proved. Pipe laying work may be carried out by local contractors from Hai Duong or Ha Noi to be appointed in relation to degree of difficulty of the work.

Construction equipment, large and heavy machinery and those driven by oil pressure are also quite less. There is no leasing system of equipment in the country and skilled operators are not available. Drilling companies are available locally and the drilling equipment and pile drivers are also available in the local market. However, the other heavy machinery and construction equipment will have to be procured from Japan in order to facilitate the construction works.

Cement and aggregate are locally available, but steel materials will have to be procured from Japan in view of the quality. The major piping material like ductile cast iron pipes are locally manufactured, though due to the quality, they should be imported from Korea, etc. Other equipment like water meters, valves, motors and electric appurtenances are to be procured from either Japan or the third country such as Singapore, etc.

(4) Operation and Maintenance Capacity of Executing Agency

There are more than 30 engineers working with the Water Supply Company at present. Some of them are expected to participate in detailed design and supervision of construction.

In addition to some 60 current staff who are engaged in operation of the existing water supply facilities, some 20 new staff will be required for operation of new facilities by the Project. Most of the present facilities are being operated and suitably maintained in spite of their superannuation. The facilities of the present Project are not basically different from the existing facilities except the intake facility, therefore the existing technical level is considered to be capable for operation and maintenance of the new facilities.

Due to chronic shortage of water supply, however, the treatment facility has been continuously operated to the limit of its capacity, hence considerations on the quality of treated water are not sufficient. Training of the newly recruited staff will be required for the new facilities. Then, technical instruction by the consultant and etc. will be programmed through the period of trial operation.

Major items of technical instruction are as follows:

Items of technical instruction	Contents
Operation program	Training with a manual for operation program.
Quantity and quality control	Quantity and quality control of water source and treated water.
Intake and transmission facilities	Training for well operation program and measures for water hammer
Sludge blanket control	Training for chemical dosing and sedimentation control

(5) Extent of Services and Grade of the Project

Scope and grade of improvement under the Project are as follows:

Service areas of the treatment facility consist of three (3) Wards (ward No. IV, V and VI) at the west and parts of two (2) Wards (ward No. I and VIII) at the east of the Central Area. They are characterized as follows:

- "the new service area" where no water supply system exists at present, and
- "the improved service area" where shortage of volume and pressure and superannuated distribution networks are prevalent.

The material of intake and transmission pipelines is selected by taking corrosiveness of raw water and operating conditions into account. Some preventive measures for water hammer are to be considered since the total length of pipeline is as long as approx. 20 km. (Result of water hammer analysis: Ref. Appendix 12)

The well pumps of intake facility are to be operated by remote control. Control panel will be set up in one of the 6 well pump houses.

The water treatment plant is to be constructed at the west of Hai Duong City. A land plot of 2.6 ha is planned where a land-fill shall be applied to raise the ground 3m above sea level determined in consideration of the past records of flooding. An access road must be improved.

The lifted raw water is observed to have iron, manganese, ammonium (less than standard value) and silica contents, and low pH values indicating acidity due to free carbonic acid. Accordingly, reflecting the results of experiments, the water treatment facilities are consisted of aeration facility, coagulant /sedimentation facility, filtration facility and etc. The sludge produced in the treatment plant will be transported to the waste disposal site after the process of sludge thickener and dry bed.

The distribution system will be of pump-boosting type from the new treatment facility. In "the new service areas," the primary distribution pipeline (dia. 250 to 400 mm) and the secondary pipeline (dia. 100 to 200 mm) are provided. The tertiary distribution pipes including house connections are to be provided and worked by the Viet Nam side. Water meters, however, are to be provided by the Japanese side. In "the improved service areas," the new primary pipelines are to be connected to the existing pipes to improve volume and pressure at strategic points. The existing distribution pipes installed more than 20 years ago will not be connected and such parts will be ended with blind valves.

The ductile cast iron pipe (inside: mortar lining) will be used for the distribution mains, and the pipeline route will be along the existing roads. Pipe diameters will be determined by a pipeline network calculation considering the water demand. The construction of railway crossing is to be undertaken by the Viet Nam side. The fire hydrant will be installed on pipelines larger than dia. 150 mm, which enables wash-out.

(6) Construction Period

The critical point of the construction work, that is the main factor to affect length of construction period, will be pipe laying work of various pipelines. Particular caution shall be taken for temporary works such as temporary road and land acquisition, since wells and most of the intake and transmission pipelines are constructed in the paddy agricultural field.

2.3.2 Basic Design

(1) Raw Water Quality and Standard Values for Drinking Water

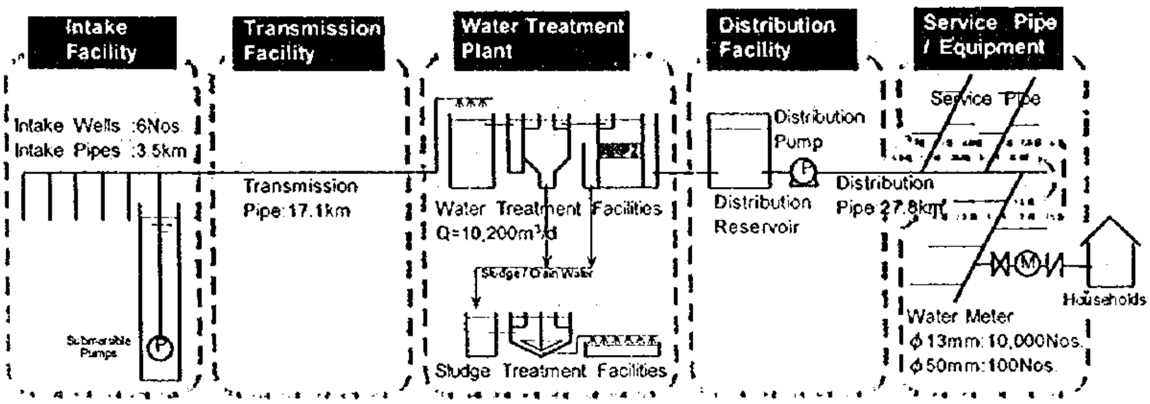
The results of water quality analysis for the raw water and their standard values for drinking water in Viet Nam are shown in Table 2.6.

Table 2.6 Raw Water Quality and Vietnamese Criteria for Drinking Water Quality

(Unit: mg/l except pH)

	pH	Iron	Manganese	Ammonium	Chloride
Raw Water	5.5 – 6.0	< 40	< 2.0	< 2.6	< 200
Standards	6.5 – 8.5	0.3	0.1	3.0	250

(2) Facility System



(a) The Cam Giang wellfield is located along a railway at 20 to 27 km west of the City, where 6 wells are drilled in the Project. Groundwater yielded is collected through the intake pipeline.

(b) The collected raw water is pumped through the transmission pipe to the treatment plant.

(c) The aeration is made to remove free carbonic acid and oxidize iron, as raw water contains high contents of free carbonic acid, iron and manganese. After the aeration for removal of free carbonic acid and for oxidization of iron content, pH control is made and followed by coagulation and rapid filtration.

(d) The distribution system consists of the distribution reservoir and the distribution pump, therefrom treated water is pumped to the service areas.

(e) The service area will be the Central Area of the Hai Duong city where the urban development works have been completed but the water supply system has not yet been provided or distribution pipes are superannuated.

(3) Design Capacity

Based on the daily average supply and taking into account the leakage (15%), daily maximum coefficient (1.3) and hourly maximum coefficient (1.35), the design capacity of the proposed facilities is summarized below. However, the major distribution pipeline of the final plan is designed capable for 135 l/c/d domestic demand unit of the initial plan for the future expansion.

Table 3.7 Design Capacity

(m^3/d)

Facility	Equipment	Initial Plan (1st Year Study)	Final Plan	
			Capacity	Assumption
Intake	Intake Pump	21,000	10,200	Daily maximum water supply + In-plant utility
	Intake Pipe	21,000	13,800	Daily maximum water supply + In-plant utility (Be capable of domestic unit water demand of 135lit/cap/d)
Transmission	Transmission Pipe	21,000	13,800	ditto to intake pipe
Water Treatment Plant	Water Treatment Plant	21,000	10,200	ditto to intake pump
Distribution	Distribution Pump	26,700	13,000	Hourly peak water supply (Daily maximum water supply×1.35)
	Distribution Pipe	26,700	17,600	Hourly peak water supply (Be capable of domestic unit water demand of 135lit/cap/d)

2.3.3 Facilities Design

(1) Intake Facility

Upon request by Hai Duong Province, the K2 (Geological survey of Viet Nam, Hydrogeological Division, K No. 2) under the Ministry of Industry carried out the hydrogeological survey in and around the Hai Duong city area for the purpose of a water supply master plan in Hai Duong province. While it is known that groundwater around Hai Duong City have higher chlorine contents, the comparatively suitable groundwater was found in Cam Giang area as a result of the groundwater investigation by JICA and the K2.

A. Required Number of Deepwells

The final design capacity of the Project is to be 10,200 m^3/day. The safe yield at a single well was 2,200 m^3/day (30.6 l/sec: 20 hours) as proved by the pumping tests. Five (5) wells are therefore needed. By adding 20 % stand-by well capacity for maintenance and emergencies, six (6) deepwells are to be constructed.

Planned number of deepwells: 6 including 1 for stand-by

B. Influence Radius of a Well and Distance between Wells

The influence radius of a well was calculated employing the Modified Cooper-Jacob equation (20 years of pumping duration, 0.8 m of drawdown). The influence radius was calculated to be 250 m. The wells are to be drilled at 500 m or more intervals.

Distance between wells: 500 m or more

C. Drawdown as a Well Group

In the case that wells in the same group are pumped at the same time, the groundwater level of each well is mutually influenced from others. In the Project, six (6) wells will be located along a straight line. In the future, additional 3 wells are to be constructed by the Viet Nam side and then 7 wells out of 9 in total will be utilized for the maximum operation.

note)

In the case that the water treatment plant be expanded to the capacity of 13,800m^3/d in order to meet the domestic water demand of 135 liters/cap/day in future, nine wells are required by the following calculation:

[Numbers of operation wells] = 13,800m^3/d / 2,010m^3/well/d = 6.76 ... 7 wells

(Intake pump capacity is to be controlled from 2,010m3/d to 1,970m^3/d by means of control valves)

[Number of standby wells] = 7wells x 20% = 1.4 ... 2 wells

[Required numbers of wells] = 7wells + 2wells = 9 wells

Supposing the future expansion (9 wells) and pumping up of these 7 neighboring wells at the same time, the largest drawdown is expected at well No. 4 which is located in the center of the aligned group of wells. Total drawdown (S) is calculated as follows:

$S = \Sigma Sn + So = 3.69 + 4.58 = 8.27$ m

Where ΣSn: Total drawdown (in meters) of well No. 4 while all wells in operation
So: Maximum drawdown (in meters) of well No. 4 in continuous pumping test

Pumps are therefore to be installed at the depth larger than that of the above added with the static groundwater level and the depth of seasonal fluctuation.

D. Land Subsidence

According to the pumping test at the test well LK6, drawdown of static level was observed to be less than 0.2 m. The effective stress, therefore, will not be increased at a measurable scale. The land subsidence is not expected by the groundwater yield.

E. Well Structure

Structure of deep-wells is in accordance with the design of test wells constructed for the experiment of the Project. The target aquifer will be the Hanoi layer, and the drilling will be made to the top of the Tertiary layer base. Depth of this base is approximately 90 m at the center of the wellfield and around 105 m at the east and the west. Depth of wells shall be 100 m in the average, taking into account the bottom of these aquifers. The diameter of well will be same as the test well. The casing diameter at the depth of pump chamber is set at 300 mm, and its length is set at 35 m. The diameter of casing and screen pipes of the other parts is 250 mm. The each length will be respectively 35 m and 65 m including sand trap.

F. Material of Casing and Screen Pipes

The casing and the screen pipes are to be made of FRP, which has good durability against corrosion. The raw water was found to contain free carbonic acid resulting in deterioration, and iron density was also high resulting in scale development in the long run. In view of stable operation for long period, the porous type screen with a high opening ratio will be used in the Project.

The opening of the screen is determined considering the inflow velocity of groundwater. The inflow velocity has to be set below 15 mm/sec according to the Japanese standard for water supply facility. The average depth of aquifer is considered to be 40 m and 30 m will be used for taking water. The porous type of screen with the opening ratio of 20 - 25 % is applied.

- Number of wells:	6 (1 for stand-by)
- Yield per well:	2,040 m^3/day (2,200 m^3/day)
- Well depth:	Approximately 100 m

- Casing size at pump: φ300 mm, average 35 m
- Casing size at intake and Screen size: φ250 mm, approx. 30 m long
- Screen type and material: Porous type (opening ratio 20%), FRP

G. Pump Head and Installed Depth

Referring to the previous section (C. Drawdown as a Well Group), the drawdown of well is calculated to be 8.27 m when the proposed yield of 2,040 m^3/day/well is continued by all 6 well. The well water level is calculated to be 9.5 m adding 1.2 m of the observed static water level. According to the report of the Project for the Water Supply System in Gia Lam Area, Ha Noi City in the Socialist Republic of Viet Nam in 1993, the seasonal fluctuation of the natural groundwater level is in a range of 4.5 to 6.2 m. Therefore, the actual pump head is calculated to be -15.7 m adding this variation. The submersible pumps will be installed at a depth of approx. - 20 m.

The actual head is to be 28.7m as the total height between the law water level and the top of aeration. Total head of pump is to be 80m, adding friction loss in the pipeline and small losses to the actual head.

- Number of pumps: 6 (1 for stand-by)
- Yield per pump: 2,040 m^3/day
- Pumping head: 80 m
- Main part material: FC/ SUS
- Motor: 380 V x 50 Hz x 3 phases
- Accessory: Air valve, Check valve, Flow Meter

H. Raw Water Intake Pipeline

The raw water intake pipeline is proposed to run along the existing railway, and it has to be placed 9 m away from the railway according to the regulations of the Ministry of Transportation. Most of the pipeline is to be laid along the existing road running in parallel with the railway. The maximum intake pipeline capacity is 13,800 m^3/day, allowing the future expansion by Viet Nam side to 135 l/c/d domestic demand unit of the initial plan.

The pH value of the raw water was measured as low as 5.5 ~ 6.0, indicating that it contains erosive free carbonic acid. The langelier's index is minus(-2.69) indicating the corrosiveness. The pipes to be used is of the inner epoxy coated ductile cast iron.

- Pipe: Ductile cast iron with inner epoxy coating
- Operating max. pressure: 10 kgf/cm^2
- Diameter: Ø 200 – 500 mm
- Length: Approx. 3.5 km

(2) Transmission Facility

The transmission facility is to pump the collected raw water through approx. 17.1 km of pipeline to the treatment plant.

A. Diameter of Transmission Pipeline

The diameter of pipeline should be set as small as possible to facilitate the ease of construction and the economical costs, but pump head becomes higher because of increasing friction losses in the pipe resulting in higher operation and maintenance costs of the facility.

The economical velocity in pipe is generally in a range from 0.8 to 1.2 m/sec. As shown in a comparison below, pipelines of Dia. 450 mm or less, and of Dia. 600 mm are more costly, and velocity of that of 600 mm is too small. That of Dia. 500 mm is therefore adopted.

Comparison of Economical Diameter with Economical Velocity

Diameter	Velocity (m/s)	Head (m)	Motor (kWh)	Cost (1,000Yen/year)		
				Power	Depreciation of pipe*	Total
φ400	1.27	130	340	14,266	15,095	29,361
φ450	1.01	100	260	10,974	17,880	28,854
φ500	0.81	80	210	8,799	19,926	28,706
φ600	0.57	60	160	6,584	23,910	30,494

* Depreciation period: 40 years

The maximum transmission pipeline capacity is also 13,800 m^3/day, allowing the future expansion from 100 l/c/d domestic demand unit of the final plan to 135 l/c/d of the initial plan.

B. Transmission Pipeline Route

The transmission pipeline is constructed along the existing railway route, and it should be located at least 9 m away from the existing railway route according to the standard of the Ministry of Transportation. Particular caution shall be taken for design of temporary road and pipeline construction which will influence to the paddy rice cultivation during the construction in the paddy field and irrigation canals. The width of temporary road is basically to be 3.0m. After construction work, the temporary road are removed and the paddy field and/or canals are restored soon.

C. Pipe Materials

The material of transmission pipeline is the inner epoxy coated ductile cast iron pipes selected by taking into consideration durability against pressure and corrosion, easiness in work and costs. Its diameter shall be 500 mm as selected in the former comparison.

Specifications of the Transmission Pipeline

- Pipe:	Ductile cast iron with inner epoxy coating
- Operating max. pressure:	10 kgf/cm^2
- Diameter:	500 mm
- Length:	Approximately 17 km
- Fittings:	Air valves and drain valves

D. River Crossing

In view of economy and easiness in operation and maintenance works, a water bridge type (L=80m) is proposed for crossing Cam Giang river. On account of its long distance, the structure of the bridge is to be supporting truss structure. Steel pipe (Dia. 500mm) is to be employed.

E. Canal Crossing

Underpassing method (pipe laying under the ground of canal bottom) is proposed for crossing canals of about 1.0m depth. To prevent pipes from moving by thrust force, anchoring with concrete block is to be employed.

F. Railway Crossing

For railway crossing, box culvert is to be constructed, the dimension of which is W1,200 x D1,200 x L6,000 x T200mm. Pipe is to be embedded in the culvert.

(3) Water Treatment Plant

1) Examination of water treatment process by model experiment

From June to September in 1997, the model experiment of water treatment of raw water in Cam Giang wellfield was implemented to decide the most appropriate treatment process(Ref. : Appendix 10). The summary of experiment is as follows:

The results of the jar test carried out in August 1997 indicate that sediments of iron hydroxide is found by adding coagulant in pH control process and iron concentration was observed below 0.3 mg/l in top of the water. Therefore, the process consisting of pH control, coagulation and rapid filtration is considered as a basic treatment process. For removing manganese, dual-layer filtration of anthracite and manganese sand was employed(Physicochemical Treatment Process). In addition to the above physicochemical treatment process, the slow filtration process which is considered as an easy operational and chemical free treatment method was also employed for the experiment to confirm the removal effect of the contents(Biological Treatment Process).

The treatment process flows of the physicochemical treatment (6 methods) and biological treatment (3 methods) are shown below:

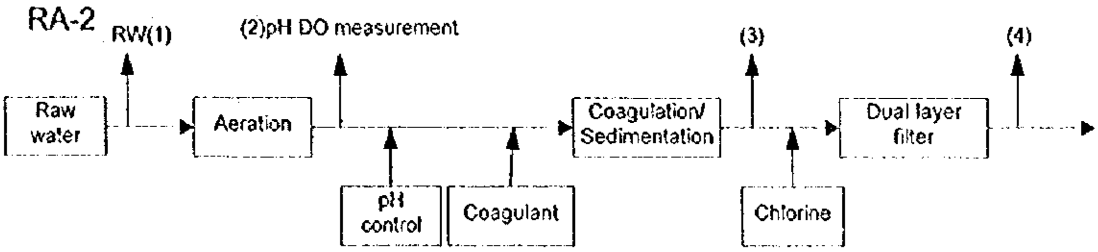
Physicochemical Treatment Process

A-1	Aeration – Rapid sand filtration (Iron)– Manganese filtration (Manganese sand)
A-2	pH control – Aeration – Coagulation / sedimentation – Rapid sand filtration (Dual layer of anthracite and manganese sand)
A-3	pH control – Rapid sand filtration (Dual layer of anthracite and manganese sand)
A-4	pH control – Aeration – Coagulation / sedimentation – Aeration - Rapid sand filtration (Iron) – Manganese filtration (Manganese sand)
A-5	Chlorination – Coagulation / sedimentation – Rapid sand filtration (Dual layer of anthracite and manganese sand)
RA-2	Improved case A-2 (Changing location of aeration) Aeration – pH control – Coagulation / sedimentation – Rapid sand filtration (Dual layer of anthracite and manganese sand)

Biological Treatment Process

B-1	Aeration – Slow filtration by coarse sand – Slow sand filtration
MB-1	Improved case B-1 (Adding slow filtration and adjusting filtration rate) Aeration – Slow filtration by coarse sand – Aeration – Slow sand filtration(1) – Slow sand filtration(2)
MB-1(2)	Improved case MB-1 (Changing location of aeration) Aeration – Slow filtration by coarse sand – Slow sand filtration(1) – Aeration – Slow sand filtration(2)

Among the aforementioned nine methods, Treatment process of RA – 2 showed the most appropriate result. Treatment process flow and the test result are as follows :



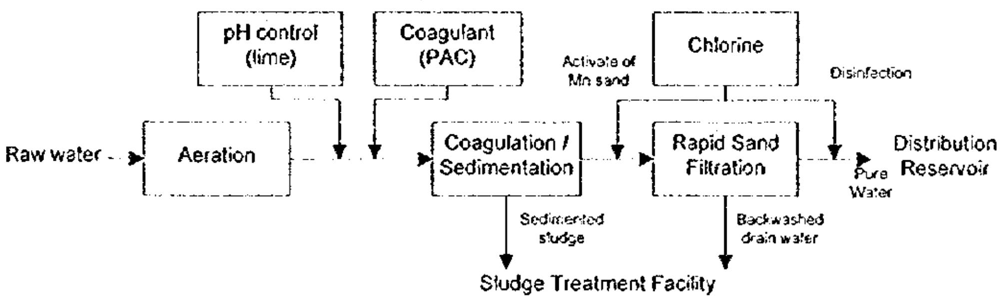
	Measured Items	Iron	Manganese	Ammonia	pH	DO
Sampling	Raw Water (RW)	45.00	1.73	2.28	5.80	0.36
	Aeration (2)	-	-	-	6.22	4.60
	Coagulation (3)	3.29	1.33	0.14	6.59	4.20
	Dual Layer Filter (4)	0.08	0.02	0.01	6.58	4.12

The oxygen dissolved in raw water was measured in a range from 0.1 to 0.7 mg/l and it was increased to a range from 4 to 6 mg/l. After aeration, pH control, PAC dosing and coagulation and sedimentation processes, 91% of iron and 94% of ammonium were removed. By the 4.3 mg/l of chlorine dosing and the dual layer filtration of manganese sand and anthracite, 7% of iron and whole of manganese and ammonium were removed.

As for manganese removal, more than 5 mg/l of chlorine dosage satisfied the criteria for drinking water standard of 0.10mg/l. The treatment process experimented in this treatment process is considered to be suitable.

2) Water Treatment Process

The water treatment process flow in the Project is illustrated below, which is employed on the basis of the model experiment results. Both of sludge extracted from the sedimentation tank and drain water from the rapid sand filter are to be treated in the sludge treatment facility.



A. Aeration

The raw water contains 80 - 120 mg/l of free carbonic acid and some 40 mg/l of silica. Generally, the iron contents react with the silica to form iron suspension by aeration. The settled silica is considered to be obstacle against proper operation of filtration process. Free carbonic acid is expected to be removed and iron is to be oxidized by aeration so that iron suspension is easily coagulated by pH control with alkali agent.

B. pH Control

The coagulation effect is improved by pH control process as a pre-treatment of coagulation process. The pH value of the raw water is adjusted by 7.0. Taking into account of effect as pH control agent, Lime is to be employed after comparing between caustic soda and lime.

C. Coagulation / Sedimentation

Poly-aluminum chloride (PAC) is selected for coagulant, as it is utilized in the Cam Thuong WTP and available at reasonable price. Its dosage is to be 3 -- 5 mg/l. The baffling type coagulation tank with about 20 min of mixing is to be employed. Since the specific gravity of iron is small, upflow type sedimentation tank (sludge blanket) is to be employed. When the floc blanket grows about 2 m thick, the absorption effect of the blanket become considerable so that the filtration time is expected to be as long as 48 hours.

D. Rapid Filtration

The rapid filtration is provided to remove the iron that is carried over from the coagulation and sedimentation process and the manganese that passed through the previous treatment process. Since filtration load by iron is small because more than 90% of iron contents are expected to be removed, the dual layer rapid sand filtration is employed, which is composed of anthracite and manganese sand. The iron floc, that is carried over with the supernatant from the sedimentation tank, is to be caught by the upper layer of anthracite. Manganese is to be oxidized and removed at the bottom layer of manganese sand. Prior to the filtration, chlorine dosage is required to activate the manganese sand. After filtration process, both of iron and manganese contents are to meet the Criteria for Drinking Water Quality.

3) Water Treatment Plant Facility Design

The water treatment plant facilities consist of aeration facility, coagulation and sedimentation tank, filtration and chemical dosing equipment. In addition, drain water reservoir, sludge thickening tank and sludge drying bed are to be constructed as a sludge treatment facility.

A. Aeration Facility

This facility is to oxidize the iron content (Fe) in the raw water to ease the succeeding sedimentation and filtration process. Free carbonic acid and ammonium contents are also removed. Following the aeration process, lime mixing chamber to control the pH value is adopted, which is to be made several minutes before dosing of coagulant.

- Capacity:	10,200 m^3/day
- Unit:	One (1) unit
- Aeration section:	L17.4 m x W 12.8 m x H 4.0 m (Height: 11.8 m)
- Receiving tank:	390 m^3 (detention time: 55 minutes)
- Mixing chamber (pH conrol):	12 m^3 (detention time: 1.7 minutes)
- Appurtenances:	Contact vessel for ammonia removal (sand filling at the bottom of the aeration section expecting biological process on sand surface)

B. Coagulation Tank／Sedimentation Tank

Coagulation tank shall be combined with sedimentation tank into one structure, and mixing is done by baffled channel. Sedimentation tank is intended to ease the filtration load by removing iron floc. The upflow sludge blanket type sedimentation tank is to be adopted in view of costs and proven efficiency in the model test. The sedimentation tank shall be structured to form the floc blanket more than 1.8 m in thickness.

Coagulation Tank

- Unit:	One (1) unit
- Dimension:	L 21.0 m x W 1.9 m x H 6.2 m
- Volume:	250 m^3
- Detention time:	35 minutes

Sedimentation Tank

- Unit:	Two (2) units
- Surface area:	L 21.0 m x W 5.0 m x 2 units = 210 m^2
- Volume:	610 m^3
- Vertical flow velocity	30 mm/min
- Detention time:	90 minutes

C. Filtration

Filter media is to be composed of the upper anthracite layer of 30 cm in depth and the bottom manganese sand layer of 70 cm in depth. Filtration rate is to be 120m/day.

- Filtration rate:	120 m/day
- Required filtration area:	10,200 m^3/d ／ 120 m/d = 85 m^2
- Numbers of filter beds:	6 units
- Filter surface per unit:	85 m^2 / 6 = 14.2 m^2
- Dimension of unit:	W 3.8m x L 3.8m = 14.44 m^2
- Filtering velocity:	10,200 m^3/day / (14.44 x 6) = 117.7 m/d
- Thickness of filter media:	1,000 mm Anthracite: 300mm Manganese sand: 700mm
- Grain size(effective diameter):	Anthracite: 1.2 mm Manganese sand: 0.6mm
- Backwash velocity:	0.6 m/min
- Backwash volume:	14.44 m^2 x 0.6 m/min = 8.7 m^3/min
- Surface wash volume:	14.44 m^2 x 0.07 m/min = 1.01 m^3/min

D. Chemical Dosage

(i) Alkali Dosage

In order to maintain the optimum condition of iron coagulation and the required level of pH value (6.5 - 8.5), pH control dosage with lime is made prior to dosage of coagulant. Using lime with 70 % of CaO content, the effective dosing range is between the maximum dosage of 59 mg/l and the average rate of 45 mg/l. The required capacity of dosing facility at the maximum value is:

$$10{,}200\ m^3/day \times 59\ mg/l \times 10^{-3} = 600\ kg/day$$

Taking lime solution content as 0.1 %, the required lime solution volume is 600 m^3/day. (600kg/d / 0.1% / 10^3kg/m^3 [0.1% lime solution specific gravity: 1.0g/cm^3])

- Dosing feeder:	600 kg/day Two units (one for stand-by)
- Mixing chamber:	W2.0m x L3.2m x H2.0m (effective depth 1.6m) = 10.2 m^3 Two units with mixer
- Dosing pump:	0.4 m^3/min x 20m Two units (one for stand-by)

(ii) Coagulant (PAC) Dosing Equipment

Based on the model experiment, dosing to the raw water shall be 10 mg/l at the maximum and 5 mg/l in the average. In the sludge thickening tank, dosing of 50 mg/l will be made to expedite the concentration process. Capacity of dosing equipment will be:

Raw water coagulation: 10,200 m^3/day x 10 mg/l x 10^{-3} = 102 kg/day
Sludge concentration: 1,500 m^3/day x 50 mg/l x 10^{-3} = 75 kg/day

PAC solution of 10 % contents (specific gravity: 1.18) is used. Solution volume will be 1.5 m^3/day including 0.85 m^3/day for raw water and 0.63 m^3/day for sludge.

- Solution tank: W 2.0m x L 3.2m x H 2.0m (effective depth 1.2m) = 7.6 m^3
  Number: 2 basins
- Dosing pump: Raw water: 0.6 l/min x 2kgf/cm^2 2units (1 stand-by)
  Sludge: 0.6 l/min x 2kgf/cm^2 2units (1 stand-by)

(iii) Chlorine Dosage

Chlorine is to be dosed for pre-filtration to remove manganese and for post-filtration to disinfect the filtered water. Dosage rates are 2.6 mg/l for pre-filtration and 2.0 mg/l for post-filtration.

Dosage volume will be:

Pre-filtration: 10,200 m^3/day x 2.6 mg/l x 10^{-3} = 26.5 kg
Disinfection: 10,200 m^3/day x 2.0 mg/l x 10^{-3} = 20.4 kg

Capacity of dosing facility will be:

- Injector: 2,000 g-effective chlorine/h 2 units (1 stand-by)
- Water pressure pump: 150 l/min x 50 m 2 units (1 stand-by)

E. Sludge Treatment

The treatment will be carried out to the sludge discharged from the coagulation and sedimentation tanks and the filtration.

Total sludge contents (dry weight):

From iron in raw water:	683.3 kg/day
From lime:	496.0 kg/day
From PAC:	15.6 kg/day
Total weight:	1,195 kg/day

The sludge volume will be:

From sedimentation:	1,000 m^3/day (as SS: 1,200 mg/l)
From filtration (backwash):	500 m^3/day
Total volume:	1,500 m^3/day

(i) Sludge Reservoir

The backwash drain is once stored in a sludge reservoir and transferred to the sludge thickener tank at a constant rate. Volume of reservoir should be able to store sludge generated in 3 hours from sedimentation and 3 times of backwash drain from filtration.

Volume needed: 1,000 m^3/day x 3/24 + 80 m^3 x 3 = 360 m^3

On assumption that the total amount of daily sludge is to be transferred in 20 hours, the rate of transfer is:

1,500 m^3/day / (20 x 60)min = 1.25 m^3/min

- Volume: W 20.4 m x L 15 m x H 2.5 m (effective depth: 1.2 m)
- Unit: One (1) basin
- Detention time: 4.8 hours
- Constant flow rate: 1,500 m^3 / (20 x 60) min = 1.25 m^3/min
- Sludge pump: 1.4 m^3/min x 10 m 2 units (1 stand-by)

(ii) PAC Dosage (the same unit is used for coagulation unit)

In the sludge thickening tank, dosing of 50 mg/l will be made to expedite the concentration process.

--- See the previous section for "Chemical Dosing Equipment"

(iii) Sludge Thickener

The thickener receives sludge to thicken and the supernatant is returned to the coagulation and sedimentation tanks. On assumption that the sedimentation velocity be 7mm/min (value from experience), using the transfer rate of 1.25m^3/min, the separation area is:

1.25 m^3/min / 7 mm/min = 178 m^2 ... 200 m^2

Considering easiness of maintenance of motor driven equipment, the thickener is to be composed of 2 units.

W10m x L10m x 2 tanks = 200 m^2

As for effective depth of the tanks, it is to be 3.5 m on account of the depth of upper clean zone and bottom settled thickened zone.

- Treatment volume: 1.25 m^3/min
- Thickening tank: W 10m x L 10m x H 3.5 m = 350 m^3 (per unit) 2 units
  Settling velocity: 7 mm/min
  Separation area: 1.25 m^3/min / 0.007 = 180 → 200 m^2
  Detention time: 4.7 hr/unit
  Discharge frequency: 1 time / 2 days
- Sludge scraper: 2 units
- Sludge withdrawal pump: 50 m^3/hr x 10 m x 7.5 kW 2 unit (1 stand-by)

(iv) Sludge Drying Bed

Thickened sludge is drawn from the thickener and sun-dried at the drying beds. Assuming the concentration of sludge as 1 % (10 kg/m^3, the specific gravity: 1.05 g/cm^3), sludge generation per day will be:

$$\{(1{,}195 \text{ kg-dry ss/d} + 75 \text{ kg-PAC/d}) / 10 \text{ kg/m}^3\} \times (1 / 1.05) = 120 \text{ m}^3\text{/day}$$

Drying beds shall consist of 7 units and the capacity of each unit is to accommodate a 6-day sludge generation. Assuming the unit capacity being 30 kg-dry-ss/m^2, surface dimension of each bed (S) will be:

$$S = (1{,}195 \text{ kg/day} + 75 \text{ kg/day}) \times 6 \times (1/30) \text{ kg/m}^2 = 254 \text{ m}^2$$

Drying duration in the model test was 5 to 6 days. Twenty one (21) day drying duration is planned taking into consideration rain and winter season. Thickened sludge shall be withdrawn once in 2 days and pumped to the drying bed in 5 to 6 hours. When one bed receives the settled sludge generated in 6 days, then another bed begins to receive it.

An operation of dry bed comprises 6 days of sledge inflow, 3 days of draining, 21 days of drying and 3 days of carrying out of dried sludge. Thus, total 33 days are needed as one operational cycle. The next cycle begins on the 43rd day. Dried sludge is assumed to have 80 to 85 % water contents, when it is carried out.

- Number of beds: 7 units
- Dimension per bed: W 8m x L 32.6m x H 2.3m (effective: 1.0m) = 260 m^3
- Total area of beds: 260 m^2 x 7 units = 1,820 m^2
- Dried sludge to be carried out:

$$(1{,}195 \text{ kg/d} + 75 \text{ kg/d}) / \{(0.2 \sim 0.15) \times 1.1 \times 10^{-3}\}$$
$$= 6 \sim 8 \text{ m}^3\text{/day}$$

(4) Distribution Facility

Distribution facility in the present Project shall be composed of a distribution reservoir, pumps, pipelines, valves, fire hydrant and other appurtenances. They need to be reasonably located in the service area with the consideration of expansion in the near future and to supply water with suitable volume and pressure required by users. In addition, the facility shall allow easy maintenance.

A. Distribution Reservoir

Capacity of the distribution reservoir (Vd) shall, according to the design standards of Ha Noi City, be equal to or more than 20 % of the daily maximum demand. The Project is to adopt this value. In addition to this, 400 m^3 of fire demand is added to meet the Japanese standards.

$$Vd = 9,651\ m^3/day \times 0.20 + 400\ m^3 \fallingdotseq 2,400\ m^3$$

- Type: Half underground (constructed in the premise of treatment plant)
- Number: 1 unit
- Capacity: 2,400 m^3
- Storage time: 6 hours
- Dimension: W 24.9m x L 30.3m x H 4.7m

B. Distribution Pump

By the distribution pumps, treated water from the reservoir will be distributed directly to users in the service area. The distributing capacity of pumps shall be capable for the hourly peak water demand (Hourly perk water demand = daily average water demand x hourly peak factor:1.35).

- Discharging capacity: 13,000 m^3/day
- Pump specifications: 3.55m^3/min x 55m 3 units (1 stand-by)
  1.95m^3/min x 55m 1 units
- Total head: 55 m
  Actual head: 2.5 m
  Friction loss: 45.0 m (C=110, 130)
  Loss around pump house: 1.5 m
  Surplus head: 6.0 m

C. Distribution Pipelines

Diameters of main distribution pipes are to correspond to the demand (hourly maximum) at the year 2000. The Project pipelines will be connected to the existing pipes at points in the existing service area, which requires improving its service volume and pressure. However, the existing pipes older than 20 years shall not be connected in fear of leakage and unexpected accidents. At these points the Project pipelines are to be terminated with the blind valves, thereby enabling connection in the future after the rehabilitation of network by the Viet Nam side.

(i) Route of Pipeline

The route of the distribution network was determined based on the site investigation during the Basic Design Study. Considerations were given to the road and housing conditions and demands at the year 2000. The distribution pipes are to be laid under the existing roads in the Project.

(ii) Material and Diameter of Pipes

The ductile cast iron pipes (DCIP) will be used. The diameter of pipe in each segment of the network was determined by Hazen - William Formula (Ref. Appendix 13). Diameters of the primary mains are 250 to 400 mm, and those of the secondary mains are 100 to 200 mm.

(iii) Pipe Pressure

Considering the housing conditions in the town, i.e. water supply only to one-storied houses, the design dynamic pipe pressure of pipes should be 0.6 kgf/cm^2. The remaining water pressure at the diversion point from the secondary main (100~200mm) to the house connection pipe (under 50mm) is 1.5kgf/cm^2 (15m).

(iv) Depth of Pipe Installation

The standard earth coverage of 1.0 m is considered.

- Material: Ductile cast iron pipe with inner mortar coating
- Operating pressure: 10 kgf/cm^2
- Diameter and length: ø 250 – 400 mm x approx. 8 km
  ø 100 – 200 mm x approx. 19 km

D. Fire Hydrant

Fire hydrants will be installed on pipes larger than 150 mm in diameter at intervals of about 150 to 300 m. The fire hydrants are of surface type in principle, but of underground type where necessary. Diameter is 65 mm or equivalent. They are to be used also for washouts.

E. Appurtenant Facilities

Stop valves will be installed at every branching of pipelines. Fittings should be protected with concrete blocks.

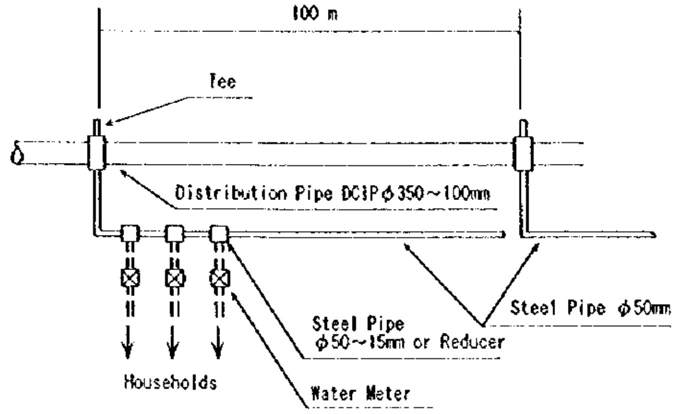
(5) House Connection

Water Meters

- Diameter 15 mm: 10,000 nos
- Diameter 20 mm: 100 nos

Polyvinyl Chloride (PVC) Pipes

- Polyvinyl chloride pipes: ø 50 mm (to be furnished by the Viet Nam side)



CHAPTER 3 PROJECT IMPLEMENTATION

Chapter 3 Project Implementation

3.1 Implementation Plan

3.1.1 Implementation Concept

The facilities to be provided by the Project are:

- Intake facilities (intake wells, well pumps, intake pipeline),
- Transmission facilities (transmission pipeline, aquabridge),
- Treatment plant (aeration, coagulation /sedimentation, filtration [removal of iron and manganese], chemical dosage facility, sludge treatment facility),
- Distribution facilities (treated water reservoir, distribution pumps, distribution pipelines, fire hydrant).

The pipe laying work reaching up to approximately 50 km that consists of the intake, transmission and distribution pipelines will require the longest construction schedule, and hence will be the critical path in the implementation. It is therefore important to schedule this part of work to be completed efficiently without trouble.

It is not practicable to utilize local contractors under the Japanese main contractor for the large civil engineering works in Hai Duong City. It is therefore assumed that experienced engineers and skilled workers be recruited directly by the Japanese contractors. Engineers of various expertise are required to be sent from Japan. Mechanical and Electrical engineers are particularly so in construction works of wells, treatment plant and distribution facility.

The executing agency of the project is by Hai Duong People's Committee, and the official channel of the Project is the Construction Service and the Water Supply Company of Hai Duong Province. The organizational structure of the project implementation is illustrated in Fig. 3.1.

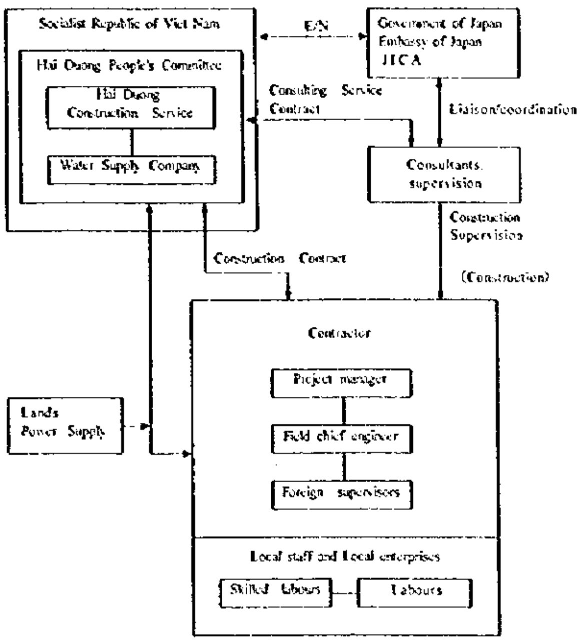


Fig 3.1 Conceptional Structure for project implementation

3.1.2 Implementation Conditions

The Project includes pipelaying in the existing service areas to improve the present supply system. It is necessary to confirm the locations of underground structure such as existing pipes and electric cables through careful field surveys in order to minimize adverse effects to those facilities as much as possible.

The projected wells will be constructed in the paddy fields. A shallow aquifer is vulnerable by influence of surface water. To prevent the target aquifer from intrusion of water from surface and shallow aquifer which is easily polluted by agrochemicals, etc., wells have to be protected by cement mortar grouting. During the construction, therefore, a careful attention should be paid in monitoring such works as cement mixing, construction procedures, etc.

The Project involves long pipelaying work in paddy fields. A care must be taken in the work to minimize influence to paddy cultivation, particularly in recovering surface with the cultivated paddy earth.

The whole facilities will be constructed on soft soil formations and hence the pile foundations will be required at the major structures such as the treatment plant. Considering the thickness of the land fill against floods and the depth to bearable foundation in the 27 m depth, the length of piles will be 34 m and 3 piles must be jointed, where very careful supervision of work is inevitable. In addition, the major structures must be water tight. A strict control of concrete quality is important.

The distribution facility will be constructed along the existing public roads in operation. Therefore, it is necessary to perform the construction work in accordance with the construction schedules prepared to avoid obstacle to transportation, accident to third persons, irregular subsidence caused by poor backfill.

The construction works will be implemented both by the Japanese side and by the Vietnamese side. The components of work by each side are shown in Table 3.1. The house connection works, which have one of the most important effect on the Project, are carried out by the Vietnamese side. In order to achieve the Project objectives as programmed, the following measures shall be implemented.

- To observe carefully the progress of house connection works from the preparation (design) stage up to the construction stage.

- To collaborate the design and construction planning and to supervise the consistency with the Project.

Table 3.1 Division for Responsibility of Work

Item	Japan	Viet Nam
Land acquisition and preparation *		O
Pacification of residents, compensation, etc.		O
Access roads to sites		O
Storage ground for construction material and equipment		O
Fence (wells, treatment plant)		O
Power substation (up to the transformer and power house)		O
Drainage from construction sites		O
House connection ($\leqq\phi$50 mm, including pipe material)		O
Wells and intake facility	O	
Transmission facilities	O	
Water treatment facility	O	
Distribution facility ($\geqq\phi$100 mm)	O	
Provision of water meters, vehicles, equipment for water quality analysis, etc.	O	

* The ground level of the Water Treatment Plant is ASL (Above Sea Level) +3.0m

3.1.3 Detailed Design and Construction Supervision

Detailed design shall be carried out in the following principles:

- Based on the field investigations, the basic design review and the detailed design will be made and the scales and quantities of the Project facility will be determined. Then, based on these studies, costs will be reviewed. Further, tender documents will be prepared in accordance with the guidelines of Japan International Cooperation Agency (JICA).
- The consultant will help the Hai Duong Province Construction Service in selecting the contractor according to the foregoing guidelines.
- It is considered that no hydrogeological investigation will be carried out for the groundwater development, since drilling of test wells, analysis of water quality, experiments of treatment process, etc. were undertaken in the Basic Design Study.
- Along route of the intake and transmission pipeline through the paddy fields, soil condition to support pipeline will be tested at several points.

The construction supervision shall be undertaken in the following principles.

- Close coordination with parties concerned in both the Japanese and the Vietnamese governments will be maintained to complete the construction as scheduled in the implementation program of the Project.
- To construct the facility in strict accordance to the design documents, prompt and proper advice will be given to the parties concerned in the implementation.
- Construction methods and technologies will be transferred to the local counterpart in order to maximize the expected effects of a grant aid project.
- Adequate advice and guidance will be given in regards to the operation and maintenance of the constructed facilities to facilitate proper operation of the Project.

- A part of the distribution network will be constructed within the existing service areas. When pipelaying work is made in these areas, a care, in sufficient collaboration with the Hai Duong Province Construction Service, shall be taken to avoid such adverse influence to residents as suspension of water supply, etc.

- The house connection works are in the charge of the Vietnamese side. In order to obtain the Project effect as programmed, the progress of house connection works shall be observed from the preparation (design) stage up to the construction stage. The collaboration shall be made for the design and construction planning, and the consistency with the Project shall be supervised.

The major consulting services in the supervision of construction are described below.

- Supervision of construction schedule and quality,
- Approval of construction materials and equipment, and construction methods,
- Inspecting or witnessing the construction processes,
- Inspection and approval of dimension and quantity as to the completed works,
- Determining variation from the original design if required, obtaining approval by JICA and the Vietnamese Government and giving such variation order to the contractor, and
- Preparation and submission of such reports as monthly reports, certificates of payment, final report, etc., in accordance with the JICA Guidelines.

The above consulting services will start from the commencement of the construction work and continue until the completion of the entire work. A resident supervisor will be assigned throughout the construction period. Since the work includes various fields such as well drilling work, pipelaying work, water treatment plant and distribution pumping station, expert engineers on these fields are assigned at times required, and an expert experienced in the entire supervision work will be assigned as the resident supervisor.

3.1.4 Procurement Plan

Construction material such as cement, aggregates, timber, pipes and fittings (except ductile cast iron pipe) to be used for the Project may be procured in the Vietnamese local market.

Most of the commonly used construction equipment are made in Russia and superannuated. It is therefore not realistic to procure construction equipment locally on the lease basis. It is proposed to import the necessary construction equipment from Japan except the diesel hammer and drilling rigs which are locally available. The procurement plan is shown in Table 3.2.

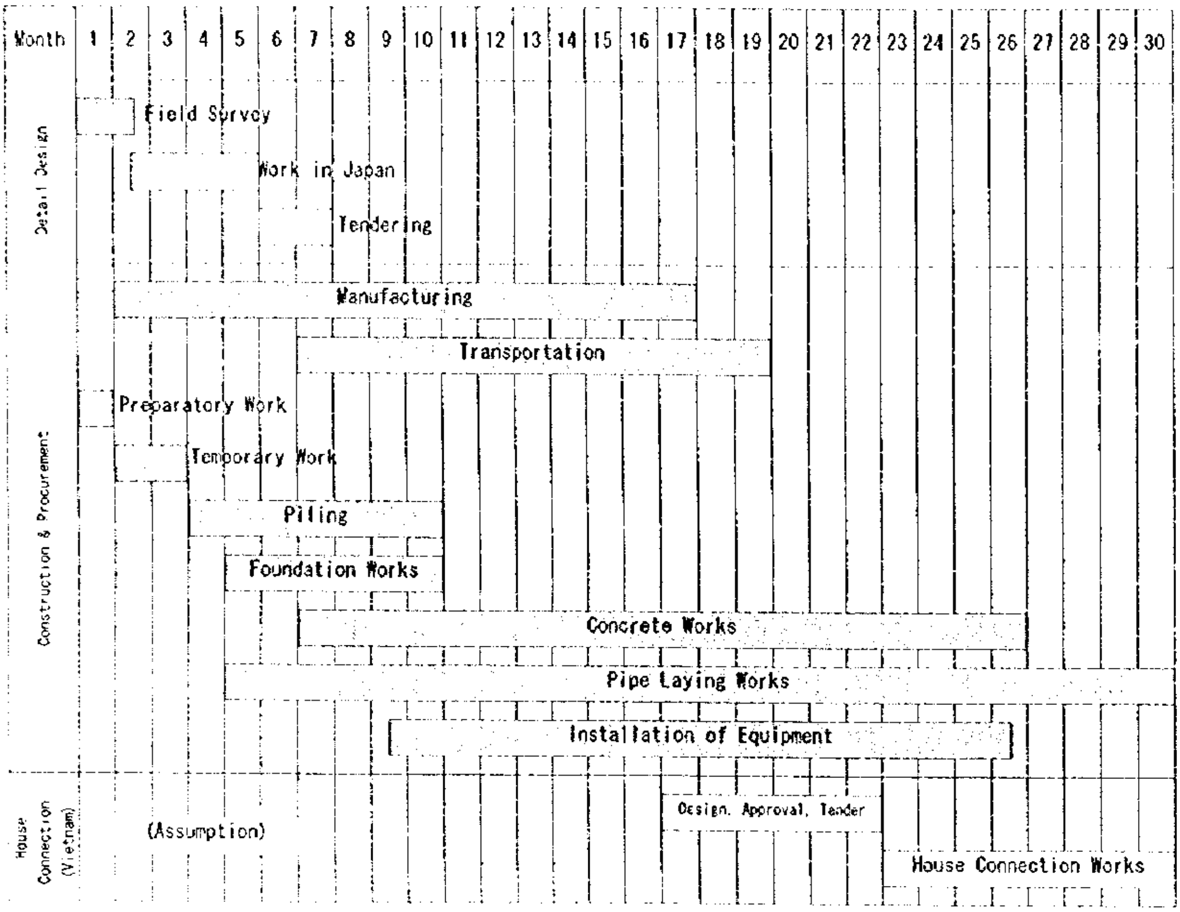
Table 3.2. Procurement Plan

Item	Specifications	Procured in: Viet Nam	Procured in: Japan	Procured in: Third Country
Construction Material				
Cement		○		
Aggregate		○		
Reinforcement bar		○		
Plywood		○		
Brick		○		
Asphalt material		○		
Metal fittings			○	
Fuel				
Gas oil		○		
Gasoline		○		
Steels				
H-beam, U-beam			○	
L-beam			○	
Pipe Material				
PVC pipe	for treatment plant	○		
FRP pipe	for well strainer		○	
Cement mortar DCIP	for distribution pipe		○or	Korea
Epoxy lining DCIP	for intake and transmission pipe		○	
Saddle branch	for distribution network		○	
Steel pipe	for treatment plant			Singapore
Concrete pipe		○		
Valves				Singapore
Water meters	ϕ 15 mm, ϕ 20 mm	○		
Treatment Facility				
Treatment equipment	filter media, collecting equipment, vacuum tank, etc.		○	
Electrical equipment	control panels, cables			Singapore
Filter media	manganese sand, anthracite		○	
Filter media	sand, gravel	○		
Pumps and others				
Well pump			○or	Denmark
Pumps and others	treatment plant		○	
Distribution pump			○	

3.1.5 Implementation Schedule

The proposed implementation schedule is shown in Fig. 3.2.

Fig. 3.2. Implementation schedule



3.1.6 Undertakings of the Recipient Country

Undertakings of the recipient country include the following items:

- Assurance of all the expenses and prompt execution for unloading and customs clearance
- Exemption of Japanese nationals from custom duties, internal taxes and other fiscal levies
- Procedures necessary for entry of Japanese nationals into the Republic of Viet Nam and stay in the country
- Conclusion of Banking Arrangements including payment of banking charges
- Issuance of Authorization to Pay
- Completion of works under the Vietnamese responsibility (stated in Section 3.1.2)
- Disposal of unexploded bombs whenever found
- Proper use, operation and maintenance of the facilities constructed and equipment provided under the Project
- Settlement of expenses unpayable under the regulations of Japan's grant aid scheme

The aforementioned works under the Vietnamese responsibility shall be completed one month prior to the commencement of the construction work.

3.2 Project Costs Borne by the Recipient Country

The construction costs borne by the Government of Viet Nam will be as follows:

(million Yen)

Item	Costs
Acquisition and preparation of land (3m above sea level), Pacification of residents, compensation, etc.	90
Access roads to each site	10
Storage for material and equipment	5
Fence (wells, treatment plant)	10
Power substation (up to the transformer and power house)	20
Drainage from construction sites	5
House connection (<ϕ50 mm, including pipe material)	70
Total	210

The cost estimation above is made by the JICA Basic Design Study Team and based on the followings.

- Date of costs estimation : October 1998
- Exchange rate : 1 US$ = Yen 136 = VND 13,103

3.3 Operation and Maintenance Plan

3.3.1 Institutional Aspect

The Water Supply Company of Hai Duong Province will operate and maintain the Project facility together with the existing water supply facility. General administration may be done with a few supplemental staff. This new (Cam Giang) system provided by the Project will require a new division for its operation and maintenance. Taking into consideration components and scale of the new facility, the following allocation of new personnel may be appropriate:

Table. 3.3 Proposed Personnel for the Project

Category	Existing Personnel	Additional Personnel by the Project	Total
Director	1		1
Deputy Director	2		2
Administration, personnel	7		7
Financial	5		5
Planning, procurement	9	2	11
Technical	8	1	9
Inspection	5	1	6
Services	5		5
Meter reading	20	7	27
Tariff collection	34	10	44
Construction, works	25	5	30
Operation 1	49		49
Operation 2	14		14
Operation 3 (Cam Giang system)		20	20
Total	184	46	230

3.3.2 Operation and Maintenance Costs

Costs of operation and maintenance for the water treatment plant were estimated by cost items in the table below.

Item	Annual costs for O&M (1,000 VND)	Share (%)
Personnel	156,000	4.9
Electric power	1,670,000	52.7
Chemicals	760,000	23.9
Sludge disposal	124,000	3.9
Fuel for vehicles	48,000	1.5
Repair	413,000	13.1
Total	3,171,000	100

On assumption that daily accounted-for water be 6,310 m³/d which is same as daily water demand, the unit production cost is calculated. Seeing the table below, the unit production cost (excluding depreciation cost) for operation and maintenance of the water treatment plant is 1,377 VND/m³.

Accounted-for water per annum	2,303,150 m³	[Daily accounted-for water (Daily average water demand)] x 365days = 6,310m³ /day x 365 days
Unit cost of accounted-for water	1,377 VND / m³	[O&M of the Project facilities] / [Accounted-for water per annum] = 171,000VND / 2,303,150m³

In addition to the above unit production cost, depreciation cost should be considered for renovation of facilities that would be more than 2,000 VND/m³. Taking the present tariff system into account, the weighted average of the tariff is expected to be 2,447 VND/m³. This can cover only the above unit production cost and a part of the depreciation cost. Therefore, it is recommended to revise the tariff system, or to find the other finance source such as cost subsidy by the Government in order to allocate the cost for renovation of the facilities.

3.3.3 Water Tariff

The water tariff of Hai Duong City has been varied as shown below:

[Unit : Dong/m³]

Category	1991	1992	1993	1994	1995	1996	1998
Domestic	380	650	850	1,100	1,300	1,400	1,600
Industrial	680	1,200	1,500	2,000	2,500	2,700	3,000
Public	1,000	2,500	3,000	3,000	4,000	5,500	6,000

The following table shows household incomes in August 1996 obtained through an interview survey.

[Unit : number of household]

No. of Valid Reply	Annual Income (x10⁵ Dong)							
	0.25-0.5	0.5-0.75	0.75-1.0	1.0-1.25	1.25-1.5	1.5-1.67	1.68-1.9	1.91-
161	11	38	32	20	40	0	20	0

About 70 % of the households have an annual income above 750,000 Dong/month.

[Unit : number of household]

No. of Valid Reply	Affordable Amount for Water Charge (Dong/month)							
	5,000 - 15,000	16,000 - 20,000	21,000 – 25,000	26,000 - 30,000	31,000 - 35,000	36,000 - 40,000	41,000 - 50,000	51,000 - 60,000
242	20	80	70	18	20	19	5	10

According to the results of interview survey, about 60 % out of the surveyed 242, of households indicated their willingness to pay an amount of 23,000 Dong/month as water charge, which corresponds to about 3 % of the monthly income of 750,000 Dong.

Should the affordable water charge set at 23,000 Dong/month, and average family size at 4.5, then the average water consumption per household will be 13.5 m^3/month (100 l/c/d x 4.5 persons x 30 days). The current rate of 1,600 Dong/m^3, i.e., 21,600 Dong/month (13.5m^3 x 1,600 Dong/m^3) is within the allowable range.

CHAPTER 4 PROJECT EVALUATION AND RECOMMENDATIONS

Chapter 4 Project Evaluation and Recommendations

4.1 Effect of the Project

The Project will make it possible to supply safe and enough drinking water for 46,000 residents in the non-service area. Accordingly, the water service ratio of the whole City will improve from 32% at present to 50% and then approach to the target ratio (56% in 2000) of the Master Plan formulated by Hai Duong Province.

The average domestic consumption per citizen will increase from 86 l/c/d at present to 93 l/c/d which will attain, though less than 135 l/c/d of the Master Plan, at least the minimum quantity necessary to cease the hourly restriction of water supply. Pipe water pressure will be also augmented by increased water volume. Thus, securing the pressure of 0.6 kg/cm^2 at the end of distribution pipelines, no suspension of water supply will occur even during the peak hours of water demand.

Water leakage in the existing service area will be improved from 35% at present to 32%. Adding the new service area proposed by the Project to the existing service area, average leakage ratio of the whole City will be reduced up to 26%. Consequently, water charge collection will be improved and then it will make the management of Water Supply Company more stable financially.

The supply service of safe water for about a half of the City population will bring about the anticipation to improve the living standard of the citizens and thereby to enhance the City's function and capacity as the Provincial Capital. Furthermore, it will contribute to the development of extensive economic zone designated by the Government of Viet Nam.

4.2 Technical Cooperation

Particular difficulty is not involved in the operation and maintenance for the facilities of the present Project. However, due to the characteristic of raw water quality, some methods adopted for the treatment process are different from the existing water treatment facilities. Therefore, learning the technical skill is considered to be important for the operation and management of new facilities.

4.3 Recommendations

Implementation of the Project will be significant as stated as above. However, it is essential to fulfill the following criteria in order to operate and maintain the facilities successfully and sustainably:

- The quality and yield of groundwater may change in the long time of operation. Therefore, the observation and monitoring of water quality and quantity should be continued even after the completion of construction to maintain the wellfield potential and stable operation of the facility.

- In general, groundwater can be used for the drinking water supply without any treatment, but the groundwater to be developed under the Project needs water treatment to provide the suitable quality. Therefore, it is necessary to establish proper water tariff system to recover these production costs. Such water tariff has to be reviewed periodically to maintain the cost recovery.

- It is most important to recruit and train the operation staff to ensure sustainable operation and management of the facilities. Properly trained and experienced technical staff may pursue the efficient operation by saving unnecessary inputs of energy and chemicals, which stand for 75 % of operation costs.

- Leakage from pipelines will bring adverse effects to the conservation of water resources and also to both cost and revenue of the water supply service. The leakage control program such as strict control of water flows incorporated in the daily operation will be necessary. There will be only minimum leakage from the new pipelines laid by the present Project. However, proper and continual inspection and maintenance for the pipelines will be essential.

- Operational experience is enough for the existing treatment method. However, since new treatment process is introduced to the new facilities such as the removal of iron and manganese, it is recommended to acquire sufficient knowledge about mechanical and electrical equipment of the new facilities.

- The concentration of iron content is high in the raw water, so that pH control becomes an important factor in the treatment process of coagulation and sedimentation in which the process control is different from the existing treatment process of surface water. Therefore, it is recommended to acquire knowledge for the treatment principle corresponding to water quality.

- It is necessary to obtain basic technical skill for the new equipment which will be set up with the new facilities of the present Project. Though there are similar equipment with the existing facilities, their functions are different. Especially, the operation and maintenance of sedimentation tank, i.e., the control of sludge blanket is the key factor. It is recommended to obtain the technical skill for the sludge blanket control.