6.3 Telecommunication System

6.3.1 Basic Development Concepts

Telecommunication System for the future should be considered from the viewpoints of the population growth, construction costs, serviceability and expandability of the System. Since Hoa Lac Urban Area has been planned to develop VNU relocation, Hoa Lac Hi-Tech Park (HTP), Phu Cat High-tech Park and Dong Xuan Residential Area by a block in the area. The System for the C21 Development should thus be considered for the purpose of each area.

Technologies for a mobile radio telecommunication and a wire communication have improved by rapid progress, and then utilized. Following telecommunication services, in particular, the mobile radio telecommunication will be available in all over the world by the beginning of twenty-first century.

(a) "IMT-200"[1] can provide a) data transmission at speed of 2M bit/sec as maximum, b) access to a telephone terminal in all-over the world and c) high quality as same as a fixed telephone.

(b) Satellite stations by some projects can accomplish high-speed data transmission at rate of 16kbit/sec to 60Mbit/sec.

In Vietnam, some people may make use of the above services by the year 2020, due to the economic growth. And if an optical fiber cable is laid to a home, which is called "FTTH – Fiber to the Home", multimedia service such as a VOD (Video on Demand) can be available at home. However, it is necessary to invest massive money and time for completion of the FTTH.

Meanwhile, a concept of "Universal Service" is given in the telecommunication infrastructure that is defined by following:

(Telecommunication) service that is essential to daily life can be supplied to any place by reasonable price and can be available to anybody.

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[1] IMT: International Mobile Telecommunication

6.3.2 Systems Development Plan

(1) General

Achievement of the Universal Service mentioned in the above shall be considered as main and important factor for the Telecommunication Network for the Master Plan. It is required to accomplish the Telecommunication Network that is cost-effective and early completion of architecture of the telecommunication infrastructure. Construction of subscriber lines between an exchange and users requires massive cable laying work, in which the architecture of the subscriber lines is a key point. The architecture of new WLL (Wireless Local Loop) system based on "radio access technology" is actualized instead of the conventional wire communication system.

Since a cordless and a cellular telephone have developed rapidly in recent year, costs of the radio equipment become economical prices in a market. The WLL system, thus, can obtain benefits, due to the development of digital technologies.

(2) Advantages of WLL system

The WLL system has some advantages to achieve the subscriber telephone services by followings:

(a) Early completion,

(b) An initial investment cost can be minimized and an extension of the system can be possible in proportion to telephone traffic (demand).

(c) Easy maintenance and good serviceability

(d) Two depending on a radio technology can categorize the WLL system, a) cellular WLL based on a mobile/telephone technology and b) digital cordless telephone using by the PHS telephone. Comparison of the WLL system is described in Table 6.3.1.

Table 6.3.1 Comparison of the WLL systems

Item/System Name	Cellular WLL	Digital cordless WLL
Typical system name	GSM, DSC1800	PHS, DECT
Transmission speed	8 – 13 Kbits/sec	32 Kbits/sec
Maximum cell radial	20km	5km
Applicable area in the world	East Europe and South-East Asia	Europe, South-East Asia and South America
Initial investment	Big: Even if the subscriber lines are a little	Small: It can be adjusted by the actual demand
Disadvantage	Detail design of the architecture is necessary to use a forecast of the demand	Design work (cell station required) depends on the actual demand

Abbreviation
GSM: Global System for Mobile Communication
DSC: Digital Selective Calling
PHS: Personal Handy-phone System
DECT: Digital European Cordless Telephone

(3) Features of PHS

PHS is categorized in the above digital cordless WLL system and has following features:

(a) Output power can be reduced, due to a usage of a micro cell, so cost of equipment required become economical,

(b) Extension of the cell/base station can be accomplished with ease, due to an application of the dynamic channel assignment that can assign a vacant channel avoiding the inter-reference at dynamic operation mode,

(c) It can guarantee the quality of telephone owing to adoption of ADPCM (Adaptive Differential Pulse Modulation) method and can make use of 32kbit/sec speed by the digital technology.

6.3.3 Phased Development Plan

Population and the subscriber demand in Phase-1A, Phase-1B and Phase-2 are forecasted in the Table 6.3.2. The demand forecast is based on the Population Framework.

Each investment in the phase shall be carried out in proportion to the demand forecast. The target-spread rates of the telephone are set about 20-set/100 pop. for Phase-1A, 25 sets for Phase-1B and 40sets for Phase-2, which can catch up with the spread rate (more than 50 sets/100 population) of a developed country nearly.

In the C21, it is required to dissolve the waiting list of the subscriber line causing shortage of the subscriber capacity and long time the construction work. Under such situations, the Telecommunication System is proposed for the Master Plan by the followings:

(a) Usage of the existing optical fiber is proposed to be the main network which connect whole C21 Development Area, where are Son Tay, Hoa Lac, Xuan Mai and Mieu Mon Urban Areas.

(b) Digital cordless WLL system using PHS is proposed to apply the subscriber lines for residential area.

(c) Optical fiber are proposed to apply to R&D Institute, high technology industry and the academic field of natural science/technology in VNU, which will require a high-speed and massive data communication.

Since this system can be provided with the less initial investment cost and can be extended in proportion to the actual subscriber demand, the exact investment cost can be estimated at implementation stage considering the actual subscriber demand. Proposed systems are shown in the Figure 6.3-1 (The communication network for C21) and Figure 6.3-2 (WLL system).

As the result of economic growth in Vietnam, volume of transmission information (voice, data and movie, etc.) at universities and HHTP and telephone traffic (demand) at residential areas will be increased year by year. In order to cope with this situation, MMAC (Multimedia Mobile Access Communication) technology can be applied. MMAC can achieve 25Mbit/sec speed as maximum using 5GHz – 25 GHz radio frequencies, which has a sharp linearity.

Meanwhile, WDM (Wavelength Division Multiplexing) technology can solve the increase of traffic demand on the existing optical fiber as backbone line. WDM can increase transmission capacity of an optical fiber using some different wavelength that multiplexing the signal in an optical fiber.

If WDM equipment are installed at both side of a optical fiber, the transmission capacity of a fiber cable become similar capacity that connecting some numbers of optical fiber (in total about 10Gbit/sec x 100).

Table 6.3.2 The Forecast of Population and Subscriber

		Phase 1A	Phase 1B	Phase 2
Target : subscriber lines/pop.		20%	25%	40%
(1)	Son Tay			
	Population	50,000	60,000	90,000
	Total demand of subscriber lines	10,000	15,000	36,000
	Additional demand of subscriber lines	10,000	5,000	21,000
(2)	Hoa Lac			
	Population	135,000	205,000	400,000
	Total demand of subscriber lines	27,000	51,250	160,000
	Additional demand of subscriber lines	27,000	24,250	108,750
(3)	Xuan Mai			
	Population	45,000	55,000	100,000
	Total demand of subscriber lines	9,000	13,750	40,000
	Additional demand of subscriber lines	9,000	4,750	26,250
(4)	Mieu Mon			
	Population	1,500	2,000	4,000
	Total demand of subscriber lines	300	500	1,600
	Additional demand of subscriber lines	300	200	1,100
	Total			
	Population	231,500	322,000	594,000
	Total demand of subscriber lines	46,300	80,500	237,600
	Additional demand of subscriber lines	46,300	34,200	157,100

6.3.4 Development Cost Estimate

Development cost of telecommunication system was estimated as multiplication of number of subscriber and the approximate unit cost per subscriber line. Estimation of the construction cost for the plan in Phase-1A, Phase-1B and Phase-2 (based on data on s1998 year) is shown in the Table 6.3.2 as follows.

Table 6.3.3 Summary of Necessary Cost

	Phase 1A	Phase 1B	Phase 2	Total
Unit Cost (US$1,000/subscriber line)	1.5	1.0	0.8	
(1) Hoa Lac	40,500	24,250	87,000	151,750
(2) Xuan Mai	13,500	4,750	21,000	39,250
Total (unit: US$ 1,000)	54,000	29,000	108,000	191,000

Source: JICA Study Team

- For Phase-1A : 1,500 USD per one subscriber line is applied. The cost includes switching equipment and other incidental materials for establishing of wireless local loop.
- For Phase-1B : 1,000 USD per one subscriber line is applied. The cost was considered the reduction of unit cost per line due to the spread of the technology.

In addition to the reduction of the unit cost per line, the cost will includes some additional switching equipment for the purpose of increasing the subscriber lines.

- For Phase-2 : Further reduction of unit cost per line will be made, which will lead 800 USD per subscriber. The cost will cover some additional facilities such as switching equipment.

- For Phase-2 : Further reduction of unit cost per line will be made, which will lead 800 USD per subscriber. The cost will cover some additional facilities such as switching equipment.

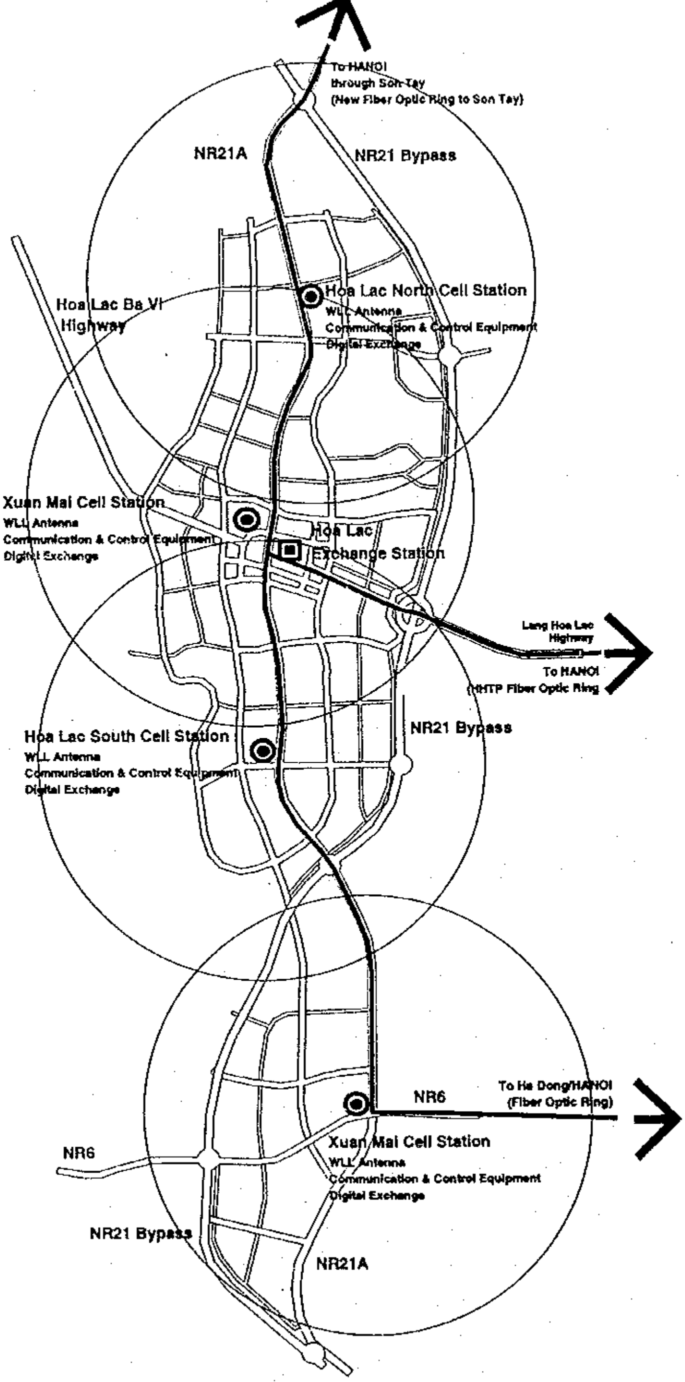


Figure 6.3.1 Telecommunication Network

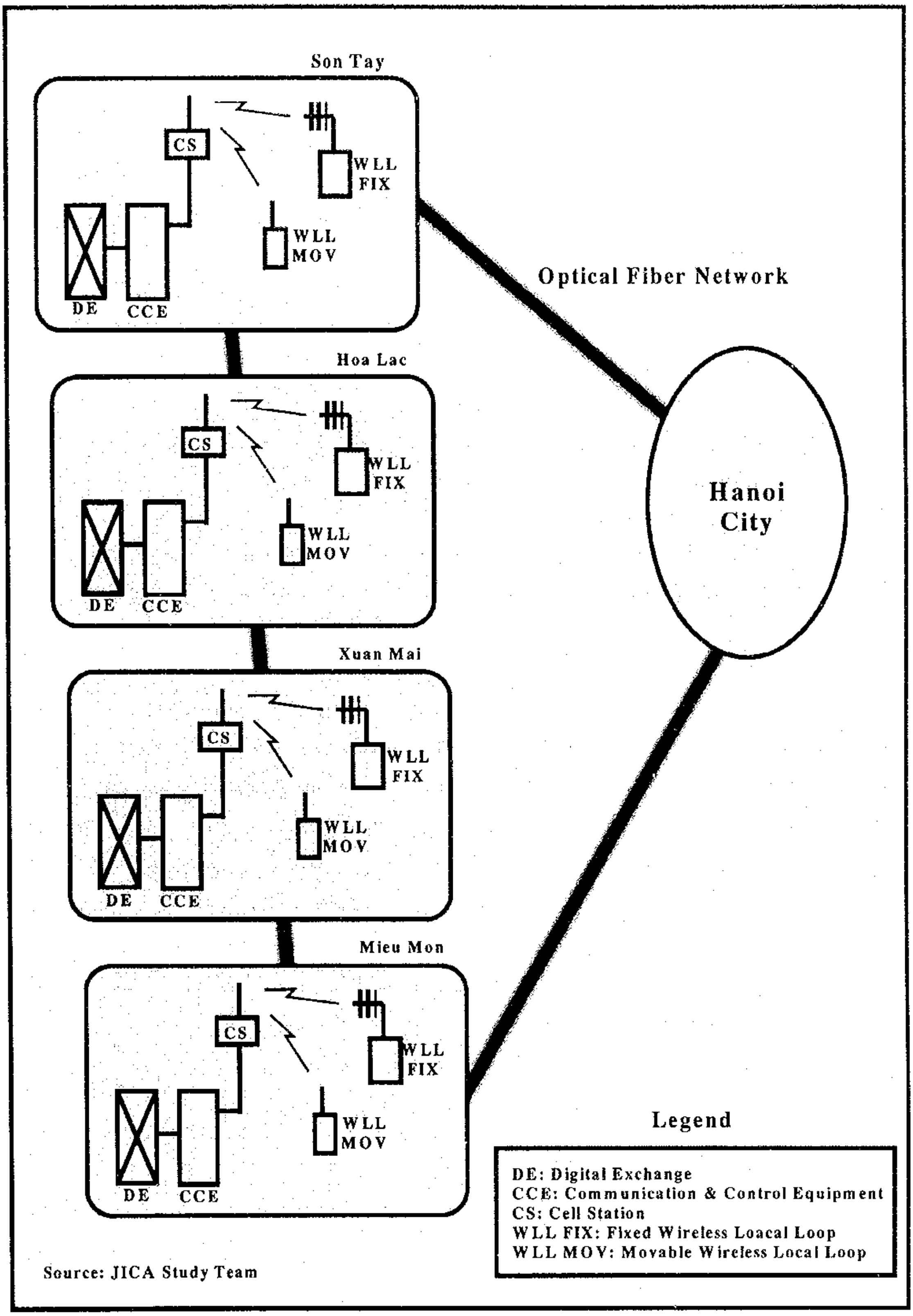


Figure 6.3.2 WLL System Diagram

6.4 Water Supply System

6.4.1 Basic Development Concept

(a) A water supply for C21 Development are proposed to cover the all inhabitants and establishments in Hoa Lac and Xuan Mai Master Plan Areas by a piped fresh water supply system.

(b) Water source for the public water supply system is proposed to be the Da River. The river water will be purified to drinkable water by a treatment plant to be located nearby the Da River intake site. The treated water should be pumped and supplied through the transmission pipeline to the proposed supply reservoir on the top of Moc Hill in Hoa Lac Urban Area.

(c) From the supply reservoir, water will be distributed by gravity force to all consumers through the distribution pipelines and networks. (See Figure 6.4.1)

6.4.2 Water Demand

Water demand in the area is estimated based on the socio-economic and land use frame for the Master Plan Area. The water demand consists of categories for domestic use and others, which are domestic, public facilities, urban centers, campus, R&D facilities and industrial establishments including high-tech industries. For the Phase-1A, the total water demand is estimated around 50,900 m^3/day on average daily basis (that require around 78,500 m^3/day on a peak day water supply capacity.) The water demand increase by year, and it will be around 182,600 m^3/day on average day (that requires around 279,200 m^3/day on a peak day water supply capacity.) in the Phase-2 as follows.

Table 6.4.1 Summary of Water Demand

Development Area	Average Daily Demand			Required Peak Day Supply		
	Phase-1A	Phase-1B	Phase-2	Phase-1A	Phase-1B	Phase-2
VNU Area	9,968	15,364	30,210	15,831	24,401	47,980
HHTP Area	10,850	18,324	32,296	16,497	27,927	49,382
C21Urban Center Area	2,673	5,380	11,499	4,246	8,544	18,263
Dong Xuan Area	8,404	16,944	39,270	13,347	26,911	62,370
Phu Cat Area	7,792	14,707	30,724	11,494	21,152	44,239
Total Hoa Lac U. Area	39,687	70,719	143,999	61,415	108,935	222,234
Total of Xuan Mai U. Area	11,218	15,440	38,650	17,085	23,347	56,974
G. Total (m3/day)	50,905	86,159	182,649	78,500	132,282	279,208

Source : JICA Study Team

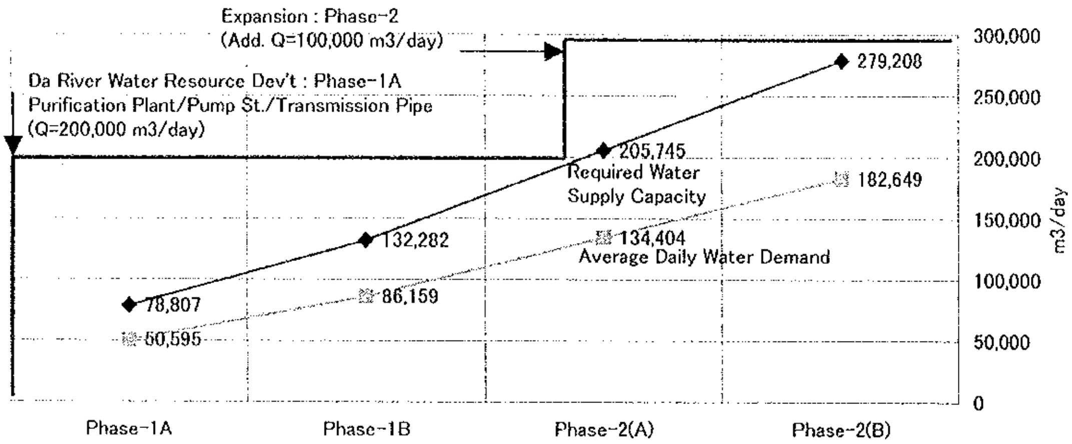
6.4.3 Development Plan of Water Supply System

The system is composed of two major items as follows

(a) Da River water transmission facilities consist of raw water intake facility, treatment plant, transmission pumps, transmission pipeline and supply reservoir, and

(b) Water distribution facilities consist of distribution mains, pipelines and service pipes.

The item (a) is planned to be constructed with a capacity of 200,000 m^3/day on the Phase-1A and additional 100,000 m^3/day facility will be required by the year 2014. (see Figure 6.4.2). The item (b) will be constructed and developed year by year following to the actual urban development. (see Figure 6.4.1).



Source : JICA Study Team

Figure 6.4.1 Da River Water Resource Development and Water Demand

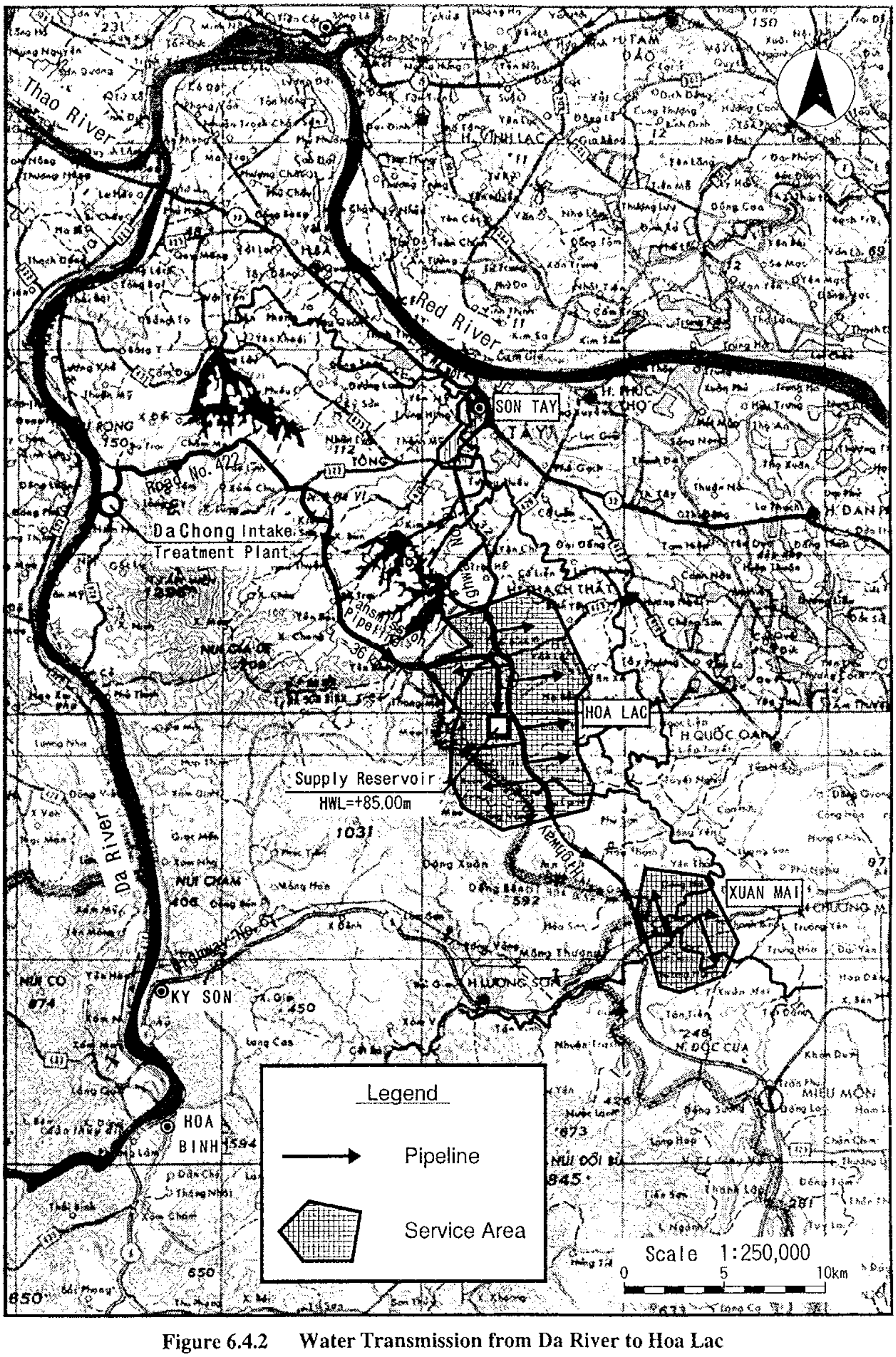
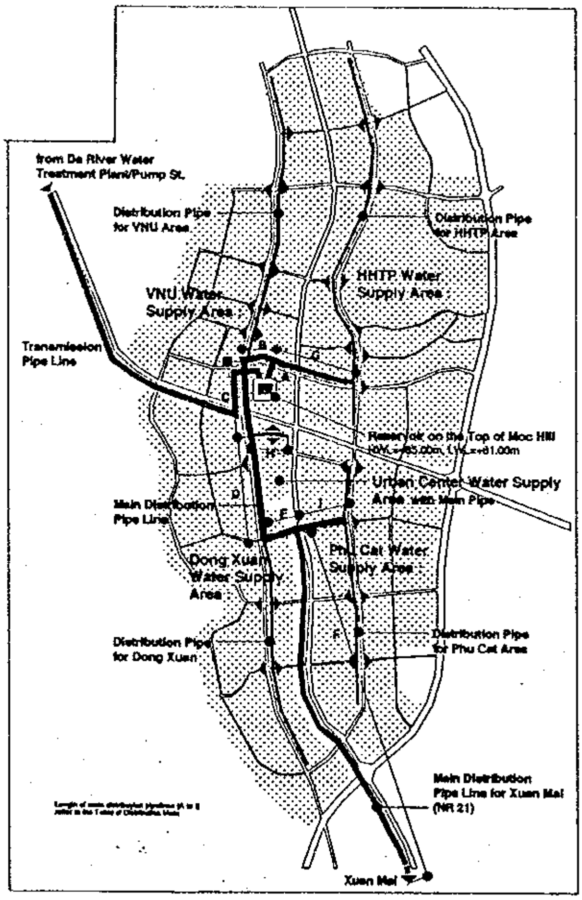


Figure 6.4.2 Water Transmission from Da River to Hoa Lac

List of Pipelines

Distribution Main

Pipe Line	Length (m)	Diameter (mm)	
		Phase-1A	Phase-1B/2
A	700	φ1,500	-
B	600	φ1,000	φ1,000
C	1,300	φ1,000	φ1,000
D	2,000	φ1,000	φ1,000
E	800	φ800	φ800
F	11,400	φ700	φ800
G	1,700	φ700	φ700
H	1,000	φ500	-
I	900	φ500	φ700



Total Length: Phase 1-A L=20,400 m (φ1,500 – φ500)

Phase 1-B/2 L=18,700 m (φ1,000 – φ700)

Total L=39,100 m (φ1,500 – φ500)

Source: JICA Study Team

Figure 6.4.3 Water Supply Plan

6.4.4 Cost Estimate

(1) Construction Cost

The Construction cost for the water supply system development is estimated according to the increased future water demand. The cost are estimated on the 1998 price basis as follows,

Table 6.4.2 Development Cost Estimate: Water Supply System

	Phase 1A	Phase 1B	Phase 2	Total
(1) Da river water transmission	86,800	-	47,400	134,200
(Intake facility, treatment plant, pumps, transmission pipeline and reservoir)				
(2) Distribution mains	7,300	4,600	2,400	14,300
(3) Distribution networks	38,700	22,400	22,400	83,500
(Distribution pipelines, service pipes)				
Total	132,800	27,000	72,200	232,000

Source : JICA Study Team

(2) Operation and Maintenance Cost

The cost for operation and maintenance of the water supply system has been preliminary estimated. It consists of costs for personnel, electric power, chemical use and repair for facility (excluding depreciation cost).

The estimated annual operation and maintenance costs on the year 1998-price basis are as follows,

- Phase-1A (year 2005) : US$ 1,708,000 /year
- Phase-1B (year 2010) : US$ 2,742,000 /year
- Phase-2 (year 2020) : US$ 5,358,000 /year

6.5 Sewerage Collection and Treatment System

6.5.1 Basic Development Concept

Sewerage system is planned to collect and treat wasted water drained from domestic and other establishments. Sewerage collection is to be made by way of sewerage pipelines constructed within the right of way of the roads in the development area. The sewerage pipelines system is proposed to separate from storm-water drainage. The direction of the pipeline flow is in principle from west toward east, due to the present topographical condition in the area.

All sewerage collected by the sewer pipelines is proposed to flow collectively into sewerage treatment plants which are located on a lowland of the east-end of the urban development area. The collected sewerage should be treated and drained into tributaries of the Tich River nearby the treatment plants. The proposed sewerage treatment plants and its locations are as follows,

Table 6.5.1 Sewerage Plants Proposed

No.	Sewerage Plant	Coverage of Sewerage Collection	Dev't Phase
No.1	Hoa Lac Center	South of University area South of HHTP area North of Dong Xuan area North of Phu Cat area	Phase-1A
No.2	Xuan Mai	Whole Xuan Mai area	Phase-1A
No.3	Hoa Lac South	South of Dong Xuan area South of Phu Cat area	Phase-1B
No.4	Hoa Lac North	North of University area North of HHTP area	Phase-2

Source: Study Team

As for industrial wasted water and the hazardous or toxic substances, the factories or the establishments should treat or pre-treat a liquid waste by their own facilities in principle.

6.5.2 Sewerage Demand and Required Capacity

The demand of sewerage volume is basically equal to the water consumption, which consist of the domestic and industrial water.

The principal figure for the sewerage demand could be estimated on the formula as follows:

- Average Daily Demand = Annual volume of water consumption divided by 365 days

- (This figure is used for cost estimation of operation and maintenance.)
- Maximum Daily Demand = Peak day demand = 1.35 times of the Average Daily Demand of domestic sewerage and 1.10 times of industrial sewerage.
- (This is used to size capacity of a sewerage plant.)
- Hourly Maximum Demand = Peak hour demand = 1.40 times of the Maximum Daily Demand divided by 24 hours.
- This is used mainly for sizing pipeline diameters.
- Additional Increment Factor (Incoming groundwater)

To set a facility of a sewer and treatment plant, leaking groundwater and rainwater coming from manholes of sewerage should be considered an additional increment factor of sewerage. It could be counted around 10% of the sewerage demand as follows,

Table 6.5.2 Sewerage Capacity

Area	Average Daily Demand			Maximum Daily Demand			Maximum Hourly Demand		
	Sewerage	Incoming Water	Total	Sewerage	Incoming Water	Total	Sewerage	Incoming Water	Total
Hoa Lac	39,687	5,220	44,907	52,204	5,220	57,424	0.8879	0.0604	0.9483
Xuan Mai	11,218	1,452	12,670	14,520	1,452	15,972	0.2544	0.0168	0.2712
Phase-1A	50,905	6,672	57,577	66,724	6,672	73,396	1.1422	0.0772	1.2194
Hoa Lac	70,719	9,259	79,978	92,598	9,259	101,857	1.5883	0.1072	1.6955
Xuan Mai	15,440	1,985	17,425	19,845	1,985	21,830	0.3521	0.0230	0.3751
Phase-1B	86,159	11,244	97,403	112,443	11,244	123,687	1.9404	0.1301	2.0705
Hoa Lac	143,499	18,835	162,334	188,351	18,835	207,186	3.2162	0.2180	3.4342
Xuan Mai	38,650	4,843	43,493	48,428	4,843	53,271	0.8993	0.0561	0.9554
Phase-2	182,149	23,678	205,827	236,779	23,678	260,457	4.1155	0.2741	4.3896

Source: Study Team

6.5.3 Facility Planning

(1) Pipelines

Main sewer pipelines should be installed in urban arterial roads, which would be coordinated with the implementation of urban development.

The maximum diameter of the main sewer will be 1,200 mm. All of sewer pipes can be utilized the reinforced concrete pipe produced in Vietnam.

(2) Sewerage Treatment Plant

Sewerage treatment system is proposed to utilize an oxidation-ditch process. Water quality of incoming sewerage will be 300 mg/l of BOD (Biological Oxygen Demand) and 300 mg/l of SS (Suspended Solids). The treated water should be the lower than 50 mg/l of BOD and 100 mg/l of SS.

The proposed sewerage treatment plants are four in total. Table 6.5.3 and Figure 6.5.1 show the proposed capacity and the proposed location of treatment plants.

Table 6.5.3 Capacity of Treatment Plants

No.	Sewerage Plant	Treatment Capacity			Land Area (ha)
		Phase-1A	Phase-1B	Phase-2	
No. 1	Hoa Lac Center	57,400	91,100	132,800	20.0
No. 2	Xuan Mai	16,000	21,800	53,300	8.0
No. 3	Hoa Lac South	-	10,700	52,600	8.0
No. 4	Hoa Lac North	-	-	21,800	4.0
	Total (M^3/day)	73,400	123,600	260,500	40.0

Source: Study Team

6.5.4 Cost Estimate

(1) Construction Cost

The construction cost for the sewerage system development is estimated according to the increased sewerage demand as well as urban development program. Construction cost are estimated on the 1998 year price basis as follows,

Table 6.5.4 Development Cost Estimate: Sewerage System

	Phase 1A	Phase 1B	Phase 2	Total
(1) Pipelines	11,100	9,600	34,600	55,300
(2) Sewerage Plant	52,200	27,600	58,200	138,000
Total (unit : US$ 1,000)	63,300	37,200	92,800	193,300

Source: JICA Study Team

(2) Operation and Maintenance Cost

The cost for operation and maintenance of the sewerage system has been tentatively estimated. It consists of costs for personnel, electric power, chemical use and repair for facilities, but not including depreciation cost.

The cost for operation and maintenance for the sewerage treatment system has been preliminary estimated. It consists of costs for personnel, electric power, chemical use and repair for facility (excluding depreciation cost).

The annual operation and maintenance cost are estimated on the 1998-year price basis as follows,

- Phase-1A (year 2005) : US$ 1.590,000 /Year
- Phase-1B (year 2010) : US$ 2.610,000/Year
- Phase- 2 (year 2020) : US$ 5.286,000/Year

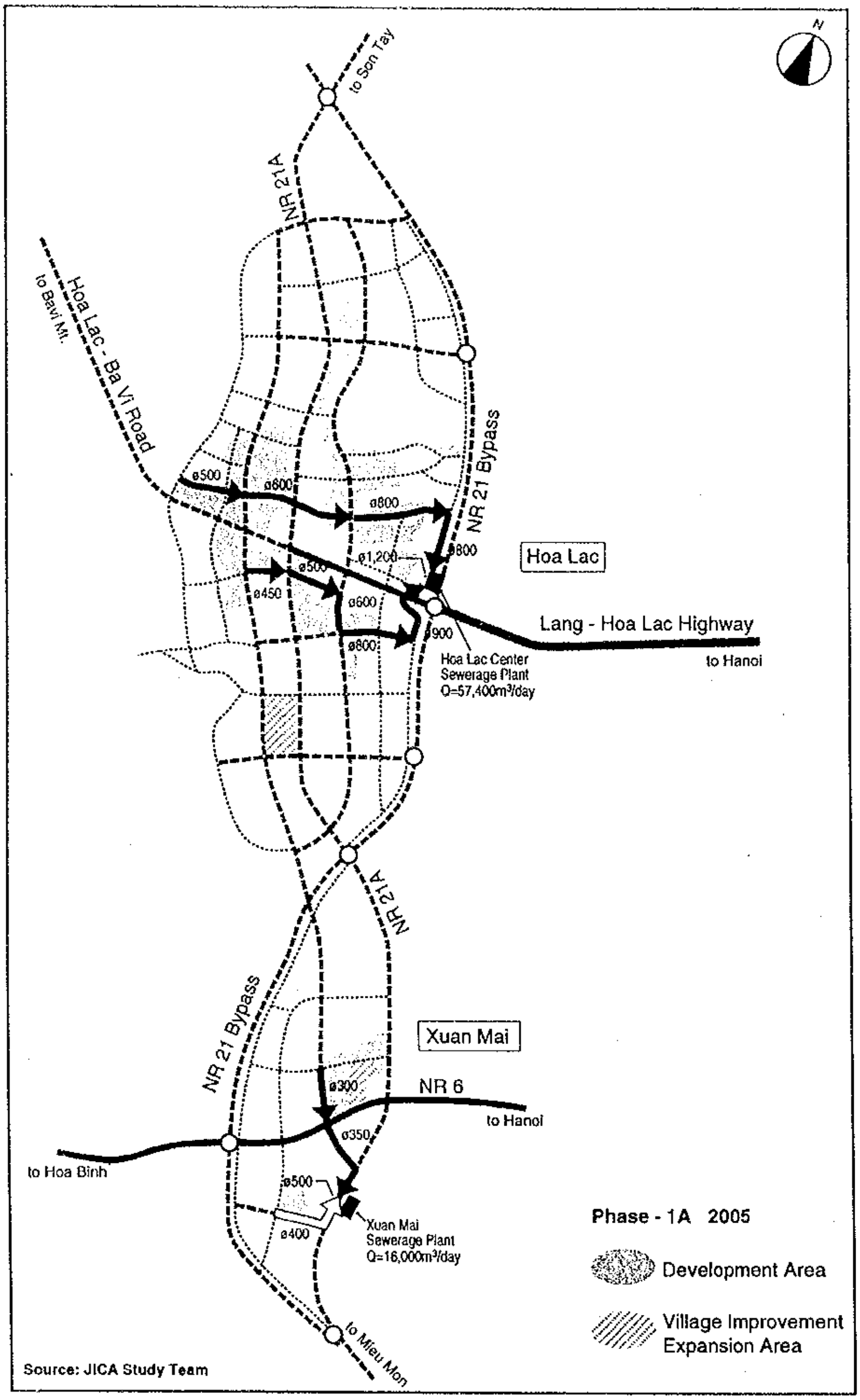


Figure 6.5.1 Sewerage Disposal Plan: Phase-1A

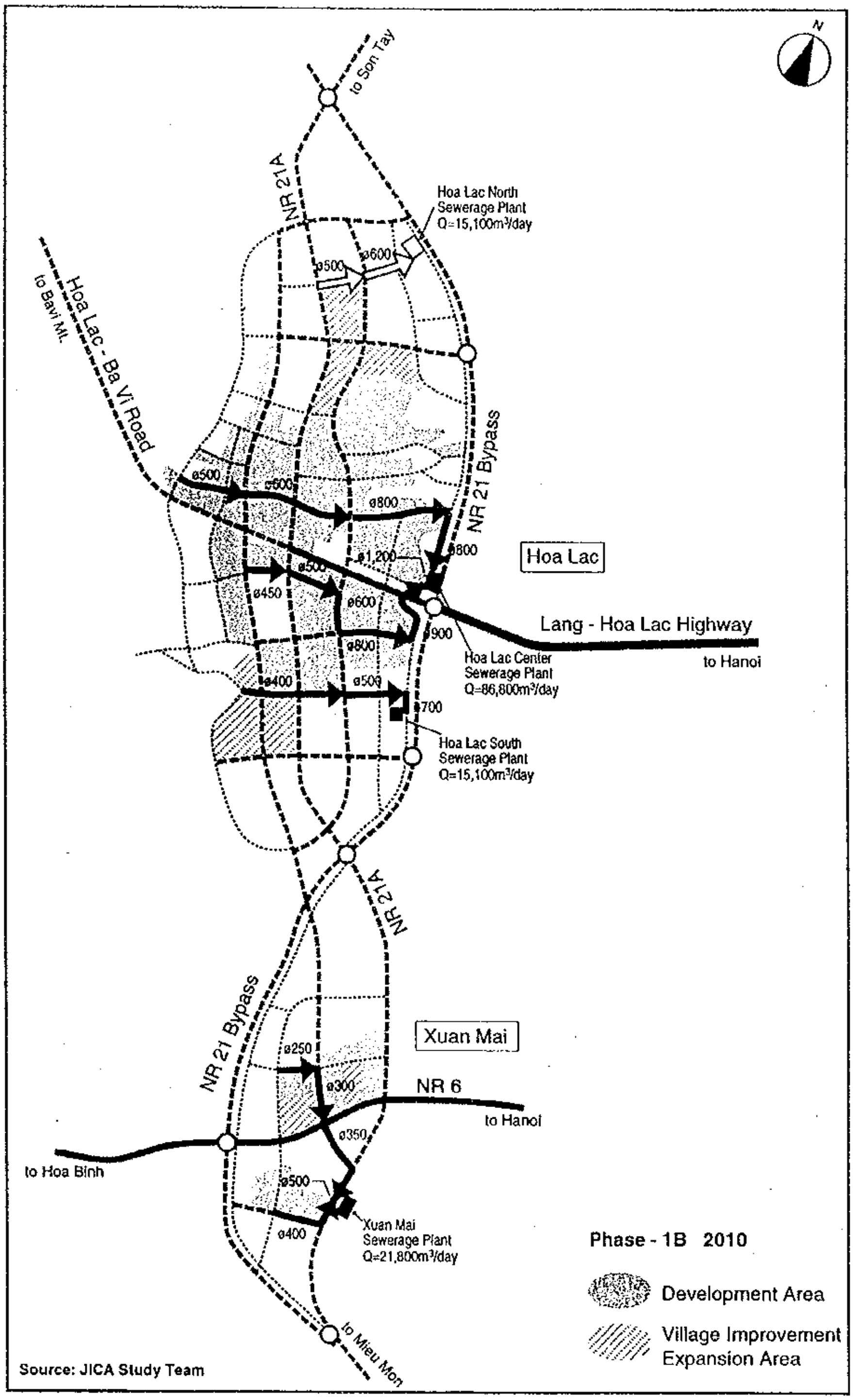


Figure 6.5.2 Sewerage Disposal Plan: Phase-1B

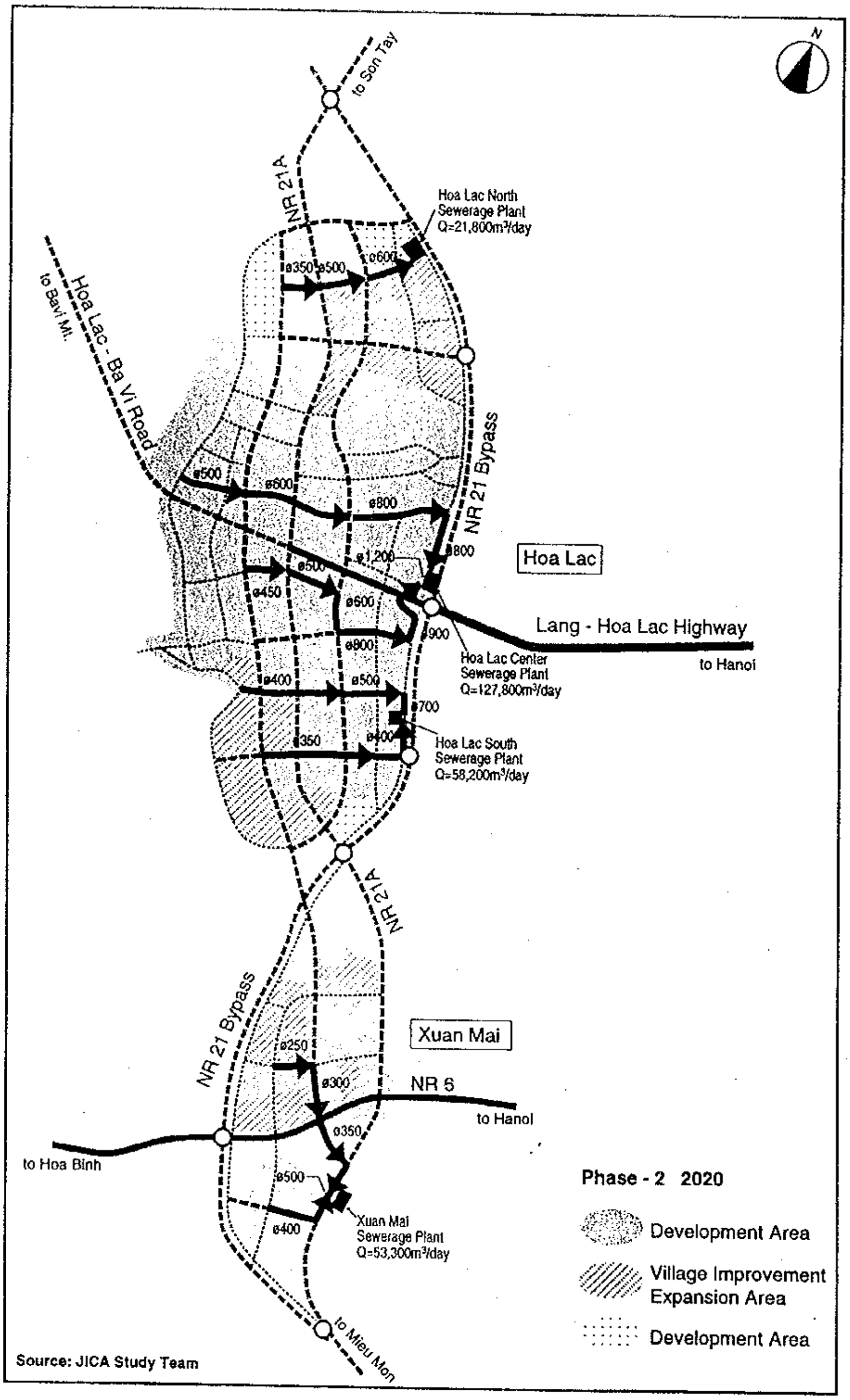


Figure 6.5.3 Sewerage Disposal Plan: Phase-2

6.6 Flood Mitigation

6.6.1 Introduction

The objectives of the study are to propose flood mitigation measures for rivers and regulating reservoirs. The Study Area, Hoa Lac and Xuan Mai Areas, is investigated from the following three (3) viewpoints of flood mitigation:

(1) Consideration to the inundation in the floodplain of Tich and Bui rivers;

(2) Regulation of flood peak increment of rivers by regulating reservoirs resulting from the urban development in the Master Plan (M/P) Area; and

(3) Consideration to flood of rivers flowing through the valley plain in the M/P Area.

6.6.2 River System

The rivers flowing through the M/P Area and their drainage basins are shown in Figure 6.6.1. The whole drainage catchment of the Hoa Lac and Xuan Mai Areas account for 86 km^2 and 36 km^2, respectively (refer to Table 6.6.1).

As for the Hoa Lac area, the terrain condition is generally higher in the west and lower in the east. Therefore, four (4) main rivers, which are small tributaries of the Tich River, flow generally from the southwest to the northeast. These rivers originate in the western mountainous area located outside the M/P Area, cross the M/P Area along the relatively flat and wide valley plains and finally pour into the Tich River flowing outside the M/P Area. The valley plain formed by these rivers is mostly utilized as rice paddy fields and some irrigation reservoirs at present. The river channels at ordinary time are relatively small; approximately 5 to 10 m in width, 0.5 to 1 m in depth near NR21A. The width of the bridges on NR21A crossing these rivers is 30 to 40 m. The Vai Ca River is the biggest in the Area with the catchment of 34.4 km^2 (H1 + H2 basin), which originates in the Nui Vien Nam mountain (1031 m) and flowing through VNU Area and the northern part of HHTP Area joining the small tributaries.

As for the Xuan Mai Area, the Bui River divides the area into the two part. There are also four (4) small rivers in the area, however, these rivers are smaller than those in the Hoa Lac area and have generally narrow valley plain. These rivers originate in the mountainous area located outside the M/P Area and flow down in the Area and pour into the Bui or Tich rivers.

The Tich River originates in the Tan Vien Mountain and flows from the north to the south parallel to NR 21A then joins the Bui river at Xuan Mai. The width of the low water channel is approximately 30 to 40 m near the Study Area. The slope of the river is extremely flat with the gradient of approximately 1/20,000 to 1/30,000.

The Bui River, a big tributary of the Tich River originates in the Bui Mountain and runs through Xuan Mai Area from the west to the east then joins the Tich River. The width of the low water channel is approximately 30 m at Xuan Mai.

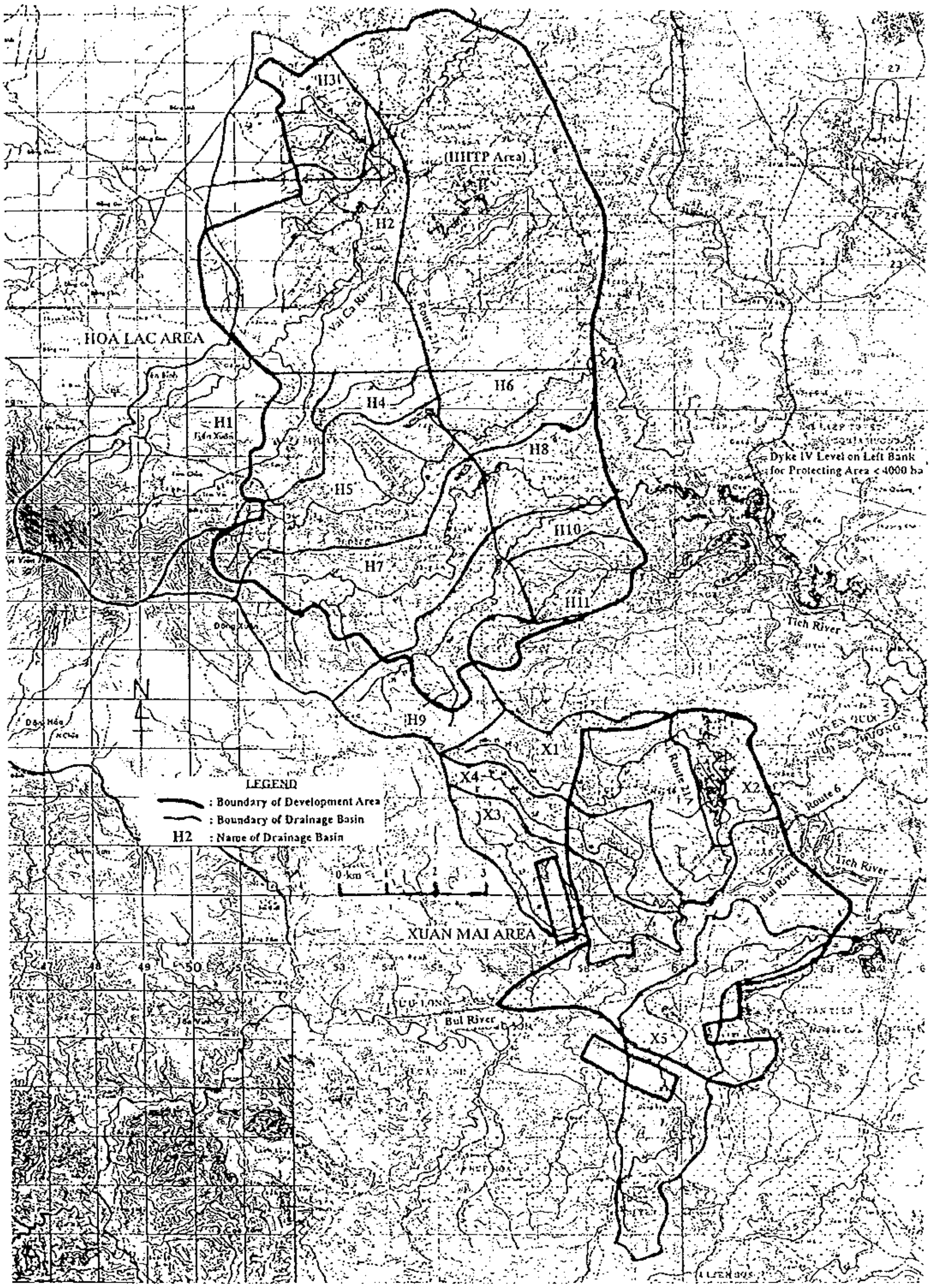


Figure 6.6.1 Location Map of River Basins for the Master Plan

Table 6.6.1 List of Flood Peak Discharge and Flood Control Capacity by River Basin

Name of River Basin	A		R	f				Q			V				Peak Discharge after Regulation
	Area	Time of Flood Concentration	Rainfall Intensity <10-year>	Runoff Ratio				Peak Discharge <Q=1/3.6*fRA>			Flood Control Capacity of Regulating Reservoir				
				Present	Future (in 2020)										
				0.6	Urban Area (U) 0.8	Others 0.6	Average f	Present	Future	Difference	Net	Gross (Net*1.2)	Proposed Capacity (Gross*2.0)	V/U	
	(km²)	(min.)	(mm/hr)		(km²)	(km²)		(m³/s)	(m³/s)	(m³/s)	(m³)	(m³)	(m³)	(m³/ha)	(m³/s)
Hoa Lac Area															
H1	18.75	66	73	0.60	0.00	18.75	0.60	229	229	0	0	0	0	0	229
H2	15.60	-	-	0.60	12.24	3.36	0.76	-	-	-	58,000	70,000	140,000	114	-
H1+H2	34.35	122	50	0.60	12.24	22.11	0.68	284	321	38	-	-	-	-	284
H3	6.80	52	84	0.60	3.60	3.20	0.71	95	113	17	13,000	16,000	32,000	89	95
H1+H2+H3	41.15	122	50	0.60	15.84	25.31	0.68	340	385	45	-	-		-	340
H4	1.50	30	112	0.60	1.50	0.00	0.80	28	37	9	8,000	10,000	20,000	133	28
H5	10.60	70	71	0.60	4.84	5.76	0.70	125	146	21	17,000	20,000	40,000	83	125
H6	4.29	-	-	0.60	4.04	0.25	0.79	-	-	-	37,000	44,000	88,000	218	
H5+H6	14.89	104	55	0.60	8.88	6.01	0.72	137	164	27	-	-	-	-	137
H7	11.73	74	68	0.60	4.19	7.54	0.68	133	151	18	13,000	16,000	32,000	76	133
H8	4.00	-	-	0.60	3.90	0.10	0.80	-	-	-	0	0	0	0	-
H7+H8	15.73	102	56	0.60	8.09	7.64	0.71	146	173	27	-	-	-	-	-
H9	7.51	50	86	0.60	2.86	4.65	0.68	107	122	14	7,000	8,000	16,000	56	107
H10	1.91	-	-	0.60	1.66	0.25	0.78	-	-	-	0	0	0	0	-
H9+H10	9.42	78	66	0.60	4.52	4.90	0.70	104	121	17	-	-	-	-	-
H7+H8+H9+H10	25.15	102	56	0.60	12.61	12.54	0.71	234	276	43	65,000	78,000	156,000	281	234
H11	3.41	39	98	0.60	3.16	0.25	0.79	56	73	18	16,000	19,000	38,000	120	56
Total	86.10				41.99	44.11						281,000	562,000		
Xuan Mai Area															
X1	9.75	53	83	0.60	6.26	3.49	0.73	135	164	29	24,000	29,000	58,000	93	135
X2	3.58	-	-	0.60	0.00	3.58	0.60	-	-	-	0	0	0	0	-
X1+X2	13.33	93	59	0.60	6.26	7.07	0.70	131	153	22	-	-	-	-	131
X3	6.13	56	81	0.60	2.94	3.19	0.70	82	96	14	10,000	12,000	24,000	82	82
X4	4.87	67	73	0.60	2.77	2.10	0.72	59	71	12	11,000	13,000	26,000	94	59
X5	11.70	105	55	0.60	6.25	5.45	0.71	107	126	20	24,000	29,000	58,000	93	107
Total	36.03				18.22	17.81						83,000	166,000		

6.6.3 Consideration to Inundation in Flood Plain of Tich and Bui Rivers

An important fact is that the Tich river is provided with continuous dyke only on the left bank (Hanoi side) as a component of polder system as described in "Hydrological Map" prepared by the Study Team and in "Red River Delta Master Plan (World Bank, 1995)". The continuous dyke system (Dyke IV Level) was constructed principally to protect the farmland around 4000 ha. On the other hand, the opposite the right bank, the Hoa Lac side, has no continuous dyke system along the Tich river, though some local dykes have been constructed.

According to the JICA HHTP Study 1998, the 100-year probable flood water stage of the Tich river at Kim Quan is estimated at about MSL 10 m (9 m in 20-year, 8.6 m in 10-year and 11 m in the emergency case of Red River*). The MOC master plan also describes that the recorded maximum water stages of the Tich river at Son Tay and the Bui river at Xuan Mai are MSL 10.0 m and 9.55 m, respectively. Accordingly, the low lying area below MSL 10 m on the right bank of the Tich river within the M/P Area is necessary to be regarded as the floodplain with the function of natural retarding basin.

The floodplain and many water bodies with the elevation below MSL 10 m are widely distributed along the Tich River. In the Hoa Lac Area, the flood plain below MSL 10 m can be seen along the valley plain mainly in the east of NR21A. In the Xuan Mai Area, the flood plain is widely distributed *1)* in the east of NR21A, *2)* around the confluence of the Tich and Bui rivers and *3)* along the upstream part of the Bui River. The flood plain in *3)* seems to be especially dangerous against flooding because the area forms enclosed storage type flood plain.

6.6.4 Required Flood Mitigation Measures

The inundation caused by the flooding of the Tich and Bui rivers will continue for a relatively long period with the extremely flat terrain of the Red River Delta. From the aspect of flood mitigation, it is required that the urban development in the floodplain below MSL 10 m be avoided as much as possible in order to secure the maximum safety against serious inundation. In the JICA HHTP Study 1998, most development is planned in the area above MSL 10 m.

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* The flooding water stage of Tich River at Kim Quan was counted at the about MSL 11m when the dick of Red River in Son Tay was cut to avoid a flooding in Hanoi in the past.

The Corridor 21 Development

It is also required that the urban development by landfill in the area below MSL 10 m is avoided as much as possible. The reason is that the landfill will give negative impact to the inundation situation: the landfill might cause not only the increase of inundation water depth but also the aggravation of flood situation to far downstream area. The negative impact of massive landfill will be bigger than that of the flood peak increment by urbanization.

Fundamentally, the river improvement of the Tich river does not belong to the category of urban development plan and should be mentioned in the context of overall flood control plan of the Tich - Day river system with the length of some hundreds kilometers. However, some comments on the dyke are stated hereunder. The Vietnamese government has proposed some dredging plan of the riverbed there is no plan to construct the continuous dyke on the Right Bank of the Tich River so far. The continuous dyke on the Right Bank seems to have little advantage. In general, the river improvement should be conducted carefully from estuary to upstream, especially for the river with quite gentle slope like the Tich and Day River system. Therefore, the flood condition will be aggravated in the downstream reaches if the continuous dyke is constructed without the river improvement in the downstream reaches in advance. The reason is that the dyke loses the retarding effect by the natural flooding plains and accordingly the flood peak discharge of the Tich River increases. The continuous dyke also seems to be economically unfeasible with the relatively narrow flood plain on the Right Bank of the Tich River.

6.6.5 Preliminary Study on Regulating Reservoir

(1) Basic Concept

Storm water runs through the terrain and the drainage pipeline to be constructed and flows into the rivers crossing the Development Area and finally drains into the Tich or Bui rivers by gravity in principle. Regulating reservoir should be provided on the downstream end of each river basin within the M/P Area in order to regulate the increment of flood peak discharge resulting from the urbanization in the M/P Area. The idea is to avoid negative impact to the area located downstream including the Tich or Bui rivers. It is concluded that the improvement of the rivers flowing through the M/P Area is not necessary because of the reasons described in (5). Drainage pumping station at the confluence of rivers and the Tich river is not introduced, since the pumping station does not seem practical because of the characteristics of the inundation situation of the Tich river mentioned above.

(2) Methodology of Runoff Analysis

The following rational formula method is applied for the runoff analysis:

$$Qp = \frac{1}{3.6} \cdot f \cdot R \cdot A$$

Where,

Qp : Flood peak discharge (m^3/s);

f : Runoff coefficient;

R : Average rainfall intensity within the time of flood concentration (mm/hr);

A : Catchment area (km^2).

"Myosyoji river method" using the rational formula is adopted for the calculation of the flood control capacity of regulating reservoir. The method can express schematically the decrease phenomena of regulation effect at downstream side caused by storage function and accordingly the capacity will become bigger (safety side against flood mitigation). The method has been commonly applied for the planning of regulating reservoir on the rivers in Tokyo Metropolitan Area in Japan.

(3) Basin Division

The drainage basins of rivers flowing through the M/P Area are divided into sub-basin by using the 1:50,000 topographical maps as shown in Figure 6.6.1. The river system is modeled for runoff analysis as shown in Figure 6.6.2. The study area of the JICA HHTP Study 1998 is excluded from the objective, since five (5) regulating reservoirs in the area have already been proposed by the study (It is noted that Tan Xa Lake has not been proposed as flood regulating reservoir).

(4) Rainfall Intensity

According to the JICA HHTP Study 1998, the Son Tay meteorological observatory located near the Study Area has not measured hourly rainfall. Accordingly, the hourly rainfall intensity is calculated by using the following rainfall intensity formula in Hanoi developed by MOC (refer to Figure 6.6.3), which has been already adopted in the JICA HHTP Study 1998:

$$I = 0.36 \cdot \frac{5426(1 + 0.25 \cdot \log P \cdot t^{0.13})}{(t + 19)^{0.82}}$$

where,

I : Rainfall intensity (mm/hr) (36 mm/hr = 100 λ/s/ha);

P : Return period (year);

t : Time of flood concentration (minutes).

The protection level of drainage is set at a 10-year return period (10 %). The proposed protection level is same as those adopted in on-going Hanoi drainage project, the JICA HHTP Study 1998 and other projects in Vietnam. The proposed level can also be compared with those adopted in the drainage project for South East Asian capitals: 5 to 10-year in Manila and 2 to 15-year in Jakarta.

(5) Time of Flood Concentration

The time of flood concentration used in the rational formula method is determined as the sum of *1)* inflow time to river channel and *2)* the flow time in river channel. The inflow time is determined by applying the standard value of 30 minutes to an area approximately 2 km^2 wide in watershed. The flow time in river channel is determined by using widely applied Kraven's empirical formula as follows:

I	above 1/100	1/100 - 1/200	below 1/200
W	3.5 m/s	3.0 m/s	2.1 m/s

T=L/W

Where,

I : Slope of river channel;

W : Flood runoff velocity;

L : Length of river channel;

T : Time of flood concentration.

The measurement is conducted by using the 1:50,000 topographical maps (refer to Table 6.6.3)

(6) Runoff Coefficient

According to "Manual for River Works in Japan" published by the Ministry of Construction of Japan, the runoff coefficient as a design value to be adopted in the rational formula method is generally indicated as follows:

Dense urban area	0.9
General urban area	0.8
Crop field and uncultivated field	0.6
Rice paddy	0.7
Mountainous area	0.7

The present land use in the Study Area is generally the mixture of rice paddy, crop or uncultivated fields and mountainous area. Accordingly the average runoff coefficient is estimated to be between 0.6 and 0.7 (approximately 0.65). However, the minimum value of 0.6 is introduced for the analysis from the conservative viewpoint for the capacity of regulating reservoir.

The runoff coefficient of 0.8 is applied for the future urban area in the year 2020 and the average coefficient of each drainage basin is determined by using a weighted average method as shown in Table 6.6.1.

The future runoff coefficient is estimated on the assumption that the study areas for flood mitigation is fully urbanized except 1) nature conservation in western mountainous area in H2, H5, H7 and H9 basins and 2) X2 basin located completely in low lying floodplain below MSL 10 m. The assumption is made from the conservative viewpoint for flood mitigation for the capacity of regulating reservoir.

(7) Flood Peak Discharge and Flood Control Capacity

The flood peak discharges in present and future land use conditions and the flood control capacity of regulating reservoirs is calculated by the established runoff model. The result is shown in Table 6.6.3 and Figure 6.6.4.

As for the flood control method of reservoir, no gate discharging will be preferable than side overflow type, since the former can regulate not only 10-year flood but also middle and small-scale floods. Accordingly, no gate discharging type is proposed for the M/P Area. However, no gate discharging type generally requires more capacity than that for side overflow type. The capacity is tentatively assumed to be the double (Gross*2.0) with that for side overflow type (Gross=Net*1.2).

The reservoirs shall be provided in principle on the downstream end of each drainage basin by constructing low earth dam with the height of 3 to 5 m (slope 1:3), spillway and relevant facilities. The proposed reservoirs are nine (9) in Hoa Lac Area and four (4) in Xuan Mai area. The irrigation ponds or reservoirs embanked by earth dam are familiar landscape in the Study Area even at present. As for the reservoir for H7 basin, existing irrigation reservoir can be utilized by some structural improvement.

The preliminary dimension of reservoirs is shown in Table 6.6.6. The preliminary layout of reservoirs is shown in Figure 6.6.3 assuming that the water depth is 2 m or more deeper in total as follows:

- 1 m : regular storage for landscape and amenity including some capacity for sediment storage; and
- 1 m or more deep level : capacity for flood control.

As can be seen in the Figure, the area of these regulating reservoirs does not seem so wide. Therefore, the reservoirs could be further expanded to create waterfront progressively from the viewpoint to upgrade an urban landscape, environment and amenity.

The proposed regulating reservoirs are included in the river and water surface area and the riverside green network area on the Land Use Master Plan as mentioned in the chapter 4.

(8) Preservation of Existing Irrigation Reservoirs

There are many irrigation ponds and reservoirs in the Study Area other than above proposed regulating reservoirs. All of those existing reservoirs take important roles not only in irrigation water supply and natural flood regulating reservoirs but also as in the creation of a better climate, landscape and environment. Accordingly, it is recommended that these existing reservoirs in the M/P Area are preserved as much as possible. The almost of those reservoirs are proposed in the Riverside Green Network Area on the Land Use Plan as mentioned in the chapter 4.

6.6.6 Consideration to Flood of Rivers in Development Areas

It is concluded that the river improvement is not required for the rivers flowing through the M/P Area because of the reasons are as follows.

It is desired that the present paddy fields along rivers is proposed to be a public open space as the Riverside Open Space Network as much as possible. The open space created by these natural rivers and valley plains is important not only as the precious waterfront landscape but also for flood retarding. The proposed urban built-up areas are set on several meters higher than the Riverside Open Space, the improvement of present rivers within the M/P Area are not required from the view point of the magnitude of 10-year flood peak discharge. The proposed Riverside Open Space along the rivers functions as high water channel in flood time.

However, hydrological investigation should be conducted on the safety level from flooding. Therefore, the relationship between the width of public open space and discharge capacity is preliminarily calculated by the uniform flow calculation based on the following Manning's formula:

$$Qp = A \cdot V = A \cdot \frac{1}{n} \cdot R^{2/3} \cdot I^{1/2}$$

Where,

Qp : Flood peak discharge (m^3/s);

A : Cross sectional area of stream (m^2);

V : Average velocity of cross sectional area of stream (m/s);

n : Manning's roughness coefficient, 0.050 for public open space along rivers;

R : Hydraulic radius (m);

I : Slope of river channel.

The result in Figure 6.6.6 is prepared only for the flood water stage of 1.5 m and 2.0 m depth of rivers. The Figure can be a simple index for the safety judgement of flooding of the urbanized area along the river. The cross section of the Riverside Open Space is assumed rectangular in the calculation and the existing narrow rivers are neglected from the small flooding impact.

For example, the 10-year flood peak discharge of the Vai Ca river running through proposed VNU area is relatively big; the peak discharge is estimated at around 290 m^3/s. If the width of the Riverside Open Space is secured 240 m or 150 m (gradient is around 1/1000), the estimated relative flooding water stage in the area becomes 1.5 m or 2.0 m, respectively. Therefore, the campus area of VNU is located on the area more than 3 m higher than the Riverside Open Space, the area will be free from 10-year probable flood.

If the accurate longitudinal profile of the flood water stage is required along the Riverside Open Space in further study stage, it is necessary to carry out the non-uniform flow calculation with river cross-section to be surveyed in future.

6.6.7 Preliminary Cost Estimation

The total direct construction cost of proposed 13 regulating reservoirs in the M/P Area is provisionally estimated on the 1998 basis as follows:

Those estimated direct construction cost for reservoirs and other direct construction cost for the riverside open space are included in the land preparation and landscaping costs for each development areas on the Chapter 7.

Table 6.6.2 Total Direct Construction Cost

Work Item	Unit	Unit Price (US $)	Area (m^2)	Length (m)	Quantity (m^3)	Amount (US $)
Earth embankment	m^3	2.5	125	3,000	380,000	950,000
Spillway and relevant facilities	nos.	-	-	-	-	950,000
Total						1,900,000

Width of Dyke Crown (m)	Height (m)	Slope Gradient	Area (m^2)
10	5	1:3	125

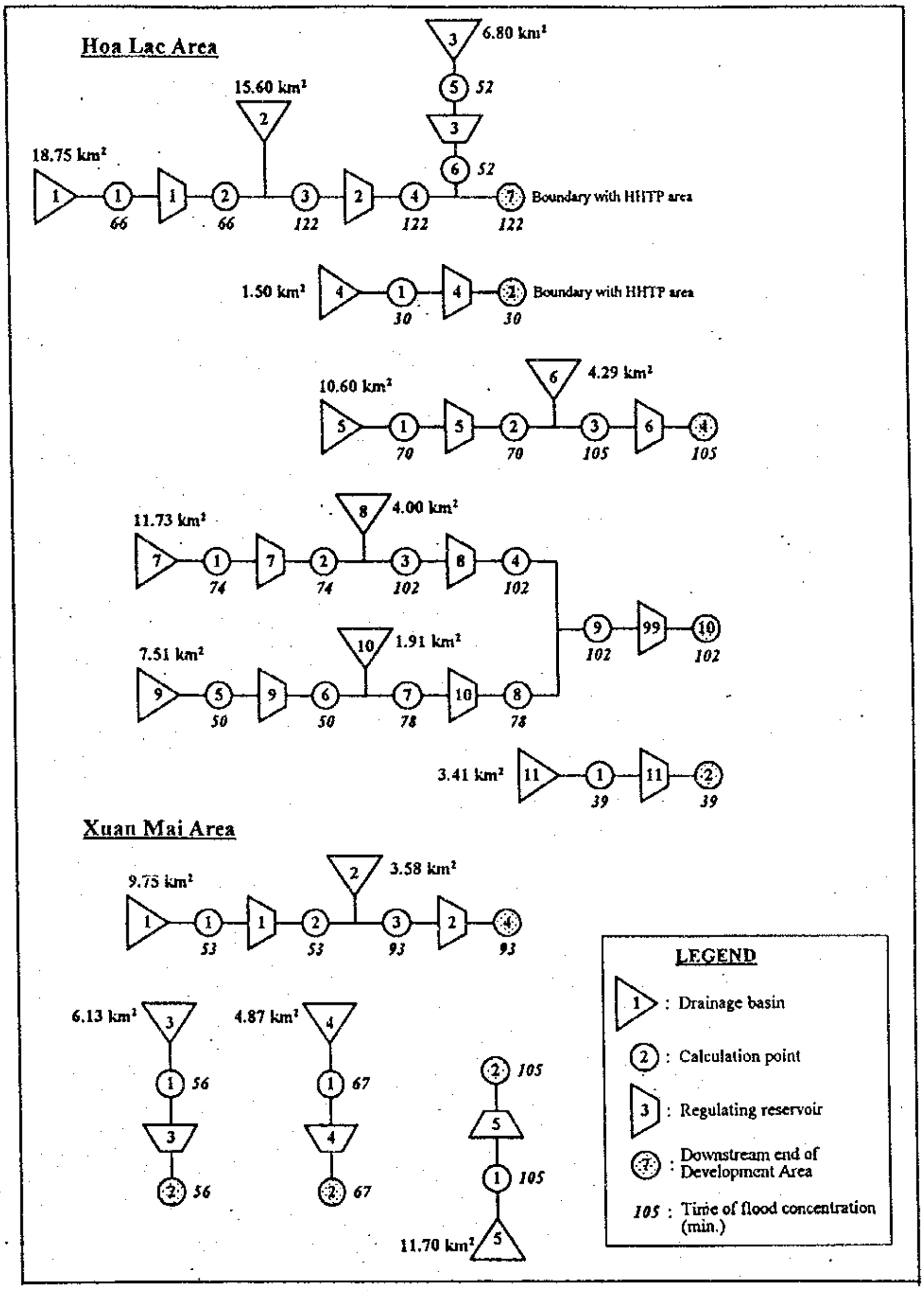
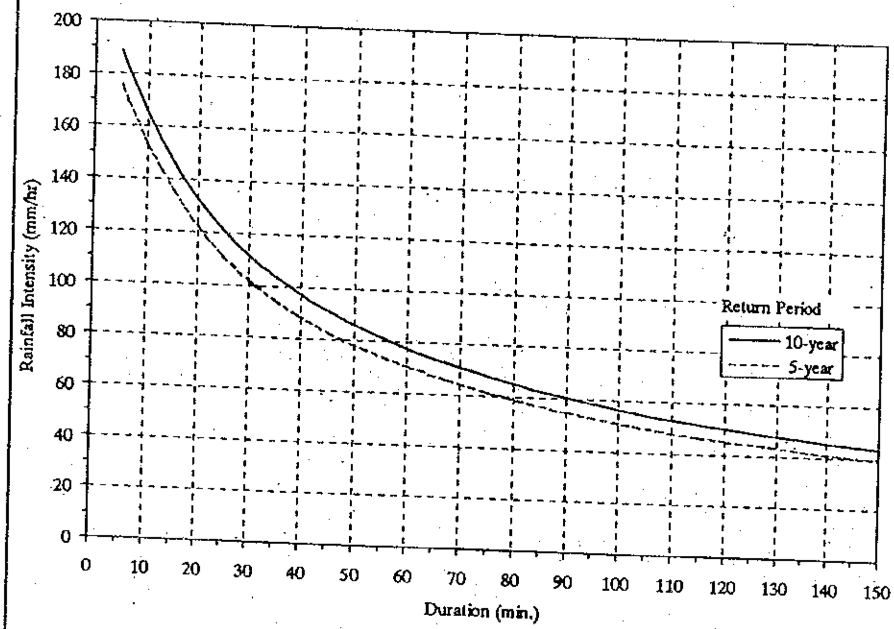


Figure 6.6.2 Diagram of Runoff Analysis by Each River Basin



Rwturn Period	5-year	10-year
Duration	Rainfall Intensity	
(min.)	(mm/hr)	(mm/hr)
5	175	189
10	153	165
15	135	147
20	122	133
25	111	121
30	102	112
35	95	104
45	83	91
60	70	77
75	61	68
90	55	60
120	45	50
180	34	38
240	28	31
360	21	23
480	17	19

note :

The Curves were calculated by using the following formula in Hanoi proposed by MOC of Vietnam:

$$I = 0.36 \cdot \frac{5426(1 + 0.25 \cdot \log P \cdot t^{0.13})}{(t+19)^{0.82}}$$

where,

I : Rainfall intensity (mm/hr) (36 mm/hr = 100 ℓ/s/ha);

P : Return period (year);

t : Time of flood concentrat ion (minutes).

Figure 6.6.3 Rainfall Intensity Curve by MOC

Table 6.6.3 Time of Flood Concentration (1/3)

Hoa Lac Area

H1+H2 Basin

Distance (km)	Accumulative (km)	Elevation (m)	Gradient I	Velocity V (m/s)	T (min)	T Accumulative (min)	T Adopted T (min)	Basin
0.00	0.00	10.0						
1.50	1.50	12.5	1/600	2.1	11.9	11.9		
2.50	4.00	15.0	1/1000	2.1	19.8	31.7		
3.00	7.00	19.0	1/750	2.1	23.8	55.6	66	H1
0.75	7.75	20.0	1/750	2.1	6.0	61.5	(122-56)	
0.90	8.65	40.0	1/45	3.5	4.3	65.8		
2.00	10.65	60.0	1/100	3.0	11.1	76.9		
1.00	11.65	80.0	1/50	3.5	4.8	81.7		
0.50	12.15	100.0	1/25	3.5	2.4	84.0		
1.15	13.30	200.0	1/12	3.5	5.5	89.5		
0.50	13.80	300.0	1/5	3.5	2.4	91.9		
		T at watershed ($A=2km^2$)			30.0	121.9	122	H1+H2

H3 Basin

Distance (km)	Accumulative (km)	Elevation (m)	Gradient I	Velocity V (m/s)	T (min)	T Accumulative (min)	T Adopted T (min)	Basin
0.00	0.00	10.0						
2.75	2.75	15.0	1/550	2.1	21.8	21.8		
		T at watershed ($A=2km^2$)			30.0	51.8	52	H3

H4 Basin

Distance (km)	Accumulative (km)	Elevation (m)	Gradient I	Velocity V (m/s)	T (min)	T Accumulative (min)	T Adopted T (min)	Basin
0.00	0.00	15.0						
1.25	1.25	20.0	1/250	2.1	9.9	9.9		
1.50	2.75	40.0	1/75	3.5	7.1	17.1		
				Total		27.0		
		T at watershed ($A=2km^2$)			30.0	30	30	H4

Note: "I" is determined by using 1:50,000 topographical maps.
"V" is determined by Kraven formulae.

Table 6.6.3 Time of Flood Concentration (2/3)

Hoa Lac Area

H5+H6 Basin

Distance		Elevation	Gradient	Velocity	T			
	Accumulative		I	V		Accumulative	Adopted T	Basin
(km)	(km)	(m)		(m/s)	(min)	(min)	(min)	
0.00	0.00	5.0						
4.25	4.25	9.0	1/1063	2.1	33.7	33.7	70	H5
1.25	5.50	10.0	1/1250	2.1	9.9	43.7	(104-34)	
1.25	6.75	20.0	1/125	3.0	6.9	50.6		
2.75	9.50	40.0	1/138	3.0	15.3	65.9		
1.00	10.50	60.0	1/50	3.5	4.8	70.6		
0.65	11.15	80.0	1/33	3.5	3.1	73.7		
		T at watershed (A=2km²)			30.0	103.7	104	H5+H6

H7+H8 Basin

Distance		Elevation	Gradient	Velocity	T			
	Accumulative		I	V		Accumulative	Adopted T	Basin
(km)	(km)	(m)		(m/s)	(min)	(min)	(min)	
0.00	0.00	5.0						
3.50	3.50	9.0	1/875	2.1	27.8	27.8	74	H7
1.00	4.50	10.0	1/1000	2.1	7.9	35.7	(102-28)	
1.75	6.25	20.0	1/175	3.0	9.7	45.4		
2.50	8.75	40.0	1/125	3.0	13.9	59.3		
1.75	10.50	50.0	1/175	3.0	9.7	69.0		
0.65	11.15	60.0	1/65	3.5	3.1	72.1		
		T at watershed (A=2km²)			30.0	102.1	102	H7+H8

H9+H10 Basin

Distance		Elevation	Gradient	Velocity	T			
	Accumulative		I	V		Accumulative	Adopted T	Basin
(km)	(km)	(m)		(m/s)	(min)	(min)	(min)	
0.00	0.00	5.0						
1.75	1.75	10.0	1/350	2.1	13.9	13.9		
1.75	3.50	15.0	1/350	2.1	13.9	27.8	50	H9
1.00	4.50	20.0	1/200	2.1	7.9	35.7	(78-28)	
1.25	5.75	40.0	1/63	3.5	6.0	41.7		
1.25	7.00	60.0	1/63	3.5	6.0	47.6		
		T at watershed (A=2km²)			30.0	77.6	78	H9+H10

H11 Basin

Distance		Elevation	Gradient	Velocity	T			
	Accumulative		I	V		Accumulative	Adopted T	Basin
(km)	(km)	(m)		(m/s)	(min)	(min)	(min)	
0.00	0.00	5.0						
1.15	1.15	7.0	1/575	2.1	9.1	9.1		
		T at watershed (A=2km²)			30.0	39.1	39	H11

Note: "I" is determined by using 1:50,000 topographical maps.
"V" is determined by Kraven formulae.

Table 6.6.3 Time of Flood Concentration (3/3)

Xuan Mai Area

X1+X2 Basin

Distance		Elevation	Gradient	Velocity	T			
	Accumulative		I	V		Accumulative	Adopted T	Basin
(km)	(km)	(m)		(m/s)	(min)	(min)	(min)	
0.00	0.00	5.0						
3.75	3.75	8.0	1/1250	2.1	29.8	29.8		
1.25	5.00	10.0	1/625	2.1	9.9	39.7	53	X1
2.50	7.50	20.0	1/250	2.1	19.8	59.5	(93-40)	
0.75	8.25	30.0	1/75	3.5	3.6	63.1		
		T at watershed (A=2km^2)			30.0	93.1	93	X1+X2

X3 Basin

Distance		Elevation	Gradient	Velocity	T			
	Accumulative		I	V		Accumulative	Adopted T	Basin
(km)	(km)	(m)		(m/s)	(min)	(min)	(min)	
0.00	0.00	5.0						
2.75	2.75	10.0	1/550	2.1	21.8	21.8		
0.85	3.60	20.0	1/85	3.5	4.0	25.9		
		T at watershed (A=2km^2)			30.0	55.9	56	X3

X4 Basin

Distance		Elevation	Gradient	Velocity	T			
	Accumulative		I	V		Accumulative	Adopted T	Basin
(km)	(km)	(m)		(m/s)	(min)	(min)	(min)	
0.00	0.00	5.0						
3.50	3.50	10.0	1/700	2.1	27.8	27.8		
1.60	5.10	20.0	1/160	3.0	8.9	36.7		
		T at watershed (A=2km^2)			30.0	66.7	67	X4

X5 Basin

Distance		Elevation	Gradient	Velocity	T			
	Accumulative		I	V		Accumulative	Adopted T	Basin
(km)	(km)	(m)		(m/s)	(min)	(min)	(min)	
0.00	0.00	5.0						
2.25	2.25	10.0	1/450	2.1	17.9	17.9		
5.75	8.00	20.0	1/575	2.1	45.6	63.5		
2.00	10.00	40.0	1/100	3.0	11.1	74.6		
		T at watershed (A=2km^2)			30.0	104.6	105	X5

Note: "I" is determined by using 1:50,000 topographical maps.
"V" is determined by Kraven formulae.

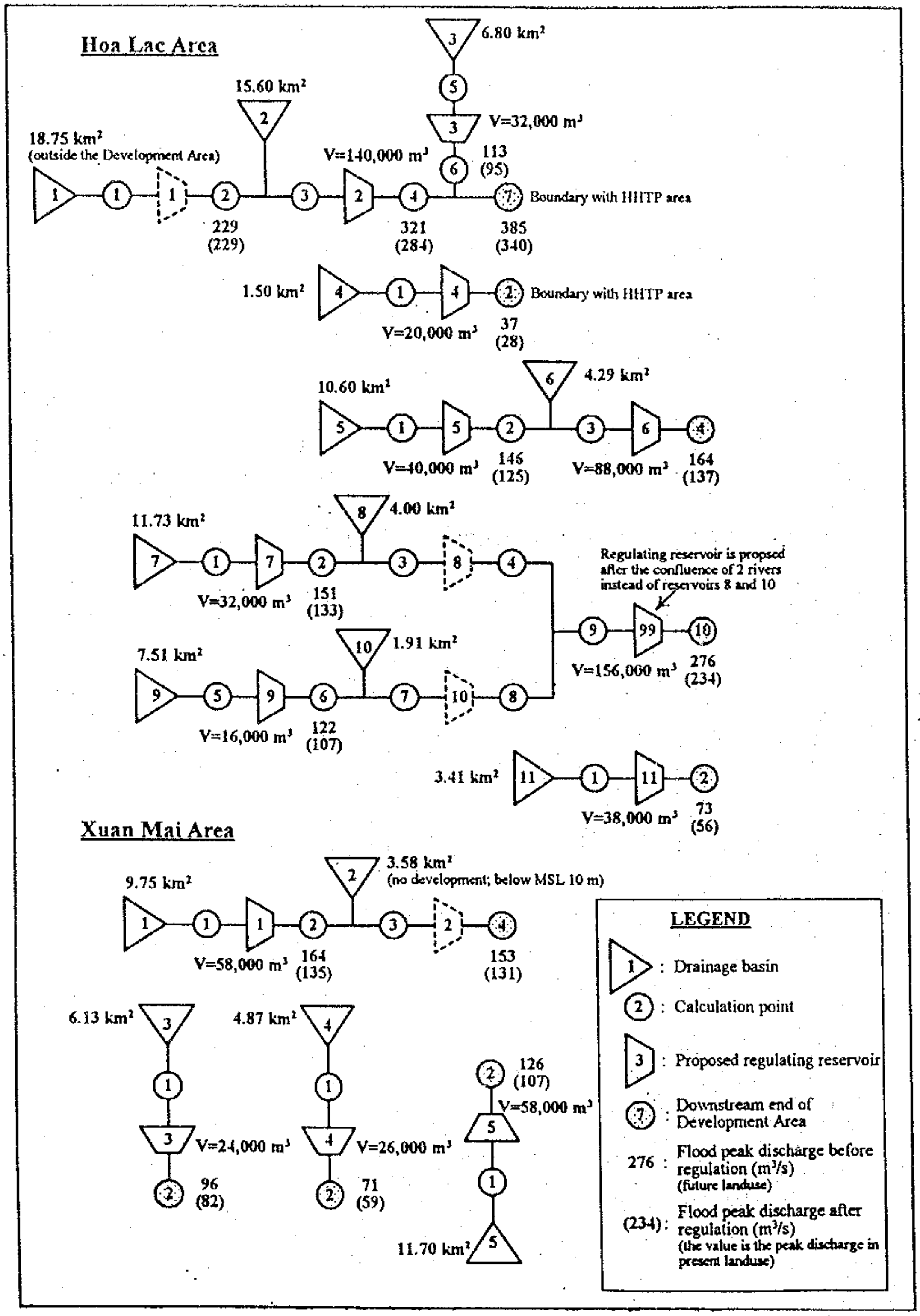


Figure 6.6.4 Flood Peak Discharge and Flood Control Capacity

Table 6.6.4 Preliminary Dimension of Regulating Reservoirs by Each river Basin

River Basin		Regulating Reservoir						
		A	V			D (=V/A)		
			Capacity					
Name	Catchment Area (km^2)	Proposed Area (ha)	Total (m^3)	Landscape, Amenity and Sediment Storage (m^3)	Flood Control (m^3)	Depth for Flood Control (m)	Present Condition at Proposed Site	Construction Method
Hoa Lac Area								
H1	18.75	-	0	0	0	-	-	-
H2	15.60	14.0	280,000	140,000	140,000	1.00	Rice paddy in valley plain	To be embanked
H3	6.80	3.2	64,000	32,000	32,000	1.00	Rice paddy in valley plain	To be embanked
H4	1.50	2.0	40,000	20,000	20,000	1.00	Rice paddy in valley plain	To be embanked
H5	10.60	4.0	80,000	40,000	40,000	1.00	Rice paddy in valley plain	To be embanked
H6	4.29	8.8	176,000	88,000	88,000	1.00	Rice paddy in valley plain	To be embanked
H7	11.73	10.0	-	Existing water body	32,000	0.32	Existing Irrigation Reservoir	To be improved
H9	7.51	1.6	32,000	16,000	16,000	1.00	Rice paddy in valley plain	To be embanked
H8+H10	5.91	15.6	312,000	156,000	156,000	1.00	Rice paddy in valley plain	To be embanked
H11	3.41	3.8	76,000	38,000	38,000	1.00	Rice paddy in valley plain	To be embanked
Total	86.10	63.0			562,000			
Xuan Mai Area								
X1	9.75	5.8	116,000	58,000	58,000	1.00	Rice paddy in valley plain	To be embanked
X2	3.58	-	0	0	0	-	(Flood plain below MSL 10 m)	-
X3	6.13	2.4	48,000	24,000	24,000	1.00	Rice paddy in valley plain	To be embanked
X4	4.87	2.6	52,000	26,000	26,000	1.00	Rice paddy in valley plain	To be embanked
X5	11.70	5.8	116,000	58,000	58,000	1.00	Rice paddy in valley plain	To be embanked
Total	36.03	16.6			166,000			

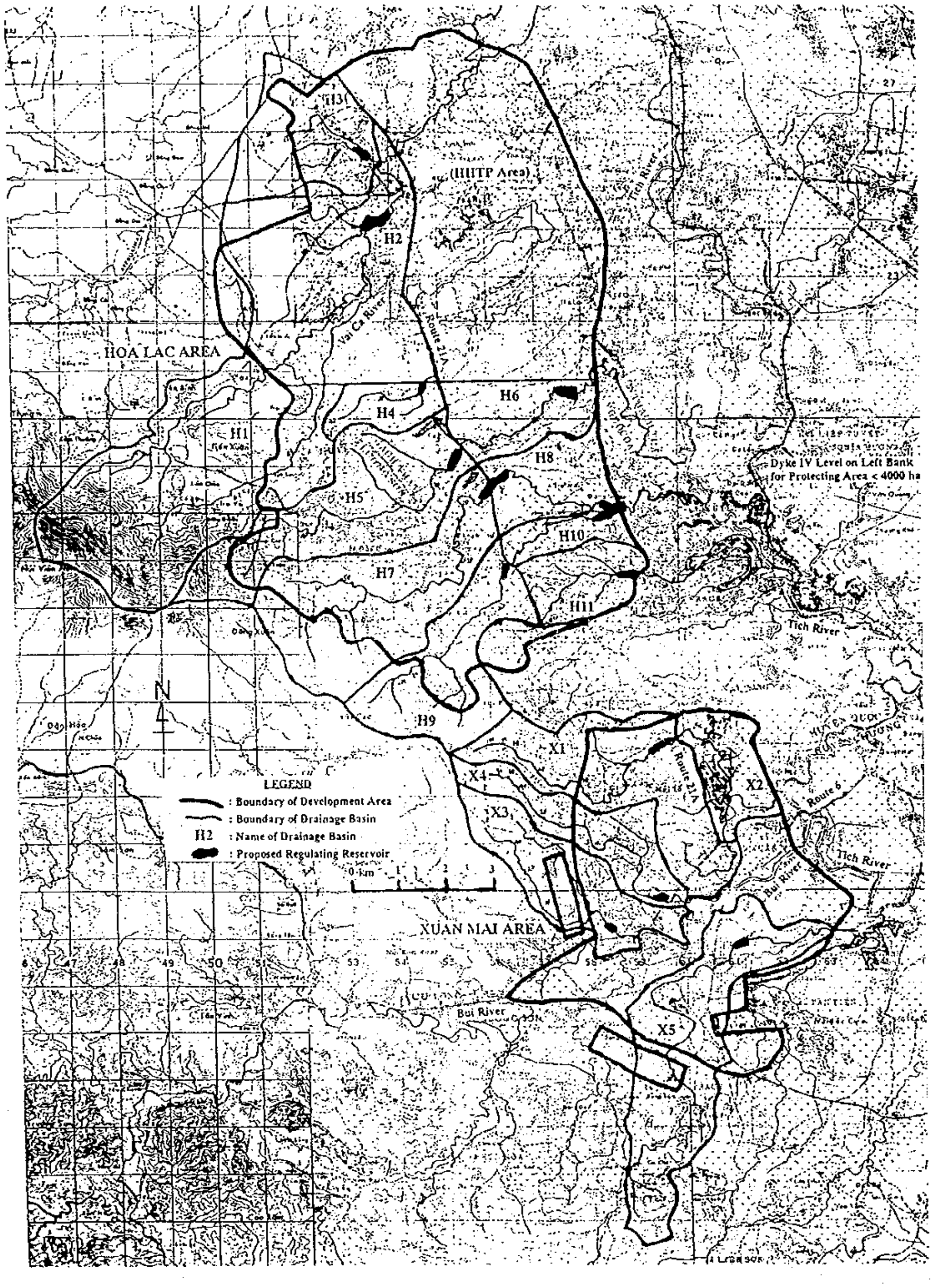
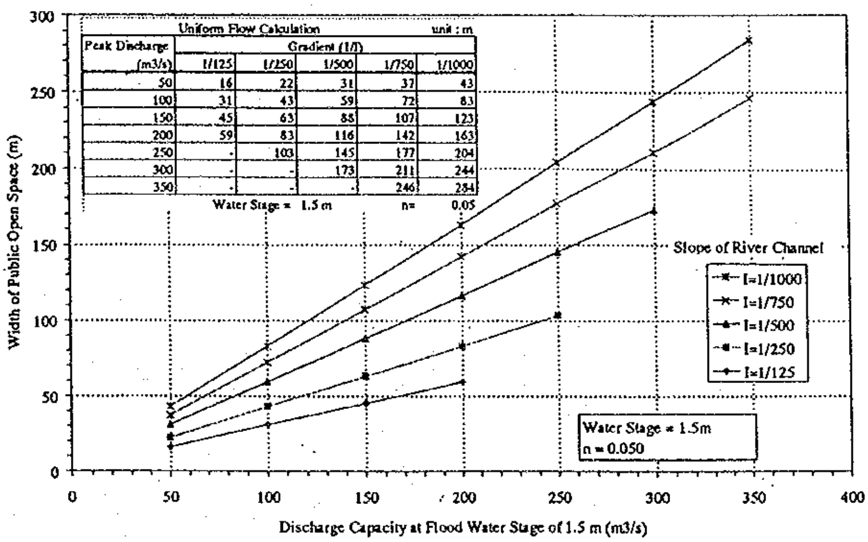


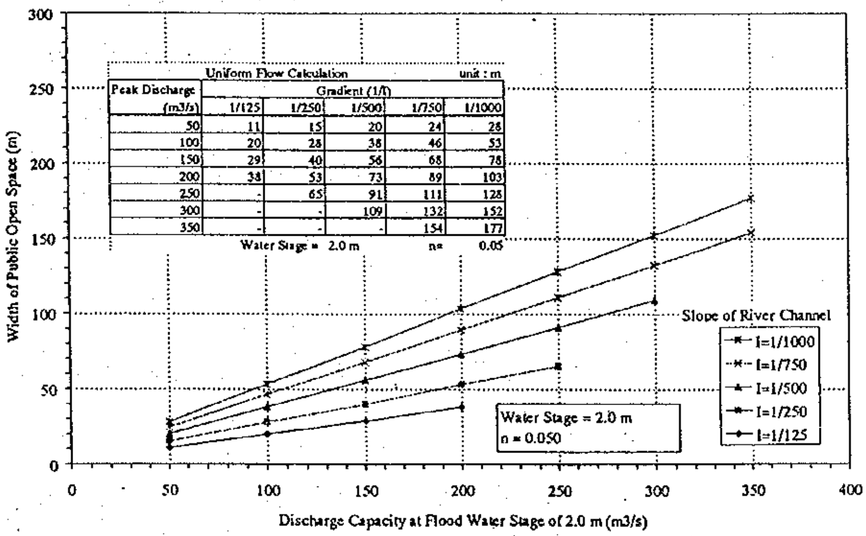
Figure 6.6.5 Preliminary Layout of Regulating Reservoirs



Uniform Flow Calculation — unit : m

Peak Discharge (m3/s)	Gradient (1/I) 1/125	1/250	1/500	1/750	1/1000
50	16	22	31	37	43
100	31	43	59	72	83
150	45	63	88	107	123
200	59	83	116	142	163
250	-	103	145	177	204
300	-	-	173	211	244
350	-	-	-	246	284

Water Stage = 1.5 m n= 0.05



Uniform Flow Calculation — unit : m

Peak Discharge (m3/s)	Gradient (1/I) 1/125	1/250	1/500	1/750	1/1000
50	11	15	20	24	28
100	20	28	38	46	53
150	29	40	56	68	78
200	38	53	73	89	103
250	-	65	91	111	128
300	-	-	109	132	152
350	-	-	-	154	177

Water Stage = 2.0 m n= 0.05

Figure 6.6.6 Width of Riverside Open Space and Discharge Capacity

6.7 Solid Waste Management System

6.7.1 Basic Development Concepts

Great many materials have been categorized under the broad heading of solid wastes. Solid wastes include the more familiar types of refuse, such as garbage, old newspapers, packing materials, yard wastes, and other items that are discarded by the typical household. Bulky appliances, old furniture, dead trees, junked automobiles, street sweepings, construction rubble, and demolition debris are other common types of solid wastes. Also included are commercial and industrial refuse materials, such as waste paper, damaged or discarded products, scrap metal, and food processing residues.

There are innumerable classifications for solid wastes. However, it is more convenient to divide solid wastes into two categories, namely municipal or urban waste and industrial waste. Municipal waste includes domestic waste, commercial and institutional waste, construction and demolition debris, street sweepings, waste from recreation areas, etc., except for industrial waste. Industrial waste means industrial residuals which are generated from a wide variety of industrial and manufacturing operations, such as scrap metal, paper and paper product wastes, and miscellaneous assortment of sludge, fly ash, waste plastics, wood, rags, and other material. Furthermore, industrial wastes are classified into two types of waste, those that present a hazard to human health and the environment as a result of improper disposal or handling, and those that do not.

At present, a few villages or communes are scattered in the proposed Hoa Lac and Xuan Mai areas and most of people are engaged in agriculture. Also some small commercial shops are observed along NR21A. At present, hygienic infrastructures such as sewage or waste disposal facilities in this area are not completed sufficiently, therefore there are no any urban hygienic means. People here collect garbage generated them and discharges it into ponds and lakes, or composite it into fertilizer.

When the Hoa Lac and Xuan Mai Development Project is implemented in the proposed area, a large quantity of waste both municipal and industrial will generate with the variety of activities within the area, and with the increase of population by natural growth, migrants and relocated families. These wastes should be managed and disposed of properly, otherwise they will eventually cause various types of problems such as water or soil contamination and also the serious threat to human health. In order to minimize the negative impacts caused by the wastes generated in the area, it is necessary to formulate a careful waste management and disposal plan such as a collection and transportation plan, a selection of available treatment and disposal method, etc. The following show the principles of waste management and disposal, which should be considered, in case of formulating waste management plans.

(1) Principles of Waste Management and Disposal

The waste management is a coherent flow at all stages from generation, handling, storage, transport, processing and ultimate disposal. Collection and transportation practices, intermediate treatment, recycling and reuse, landfill and etc. are included in above stages. Figure 6.7.1 shows the overall waste treatment flow.

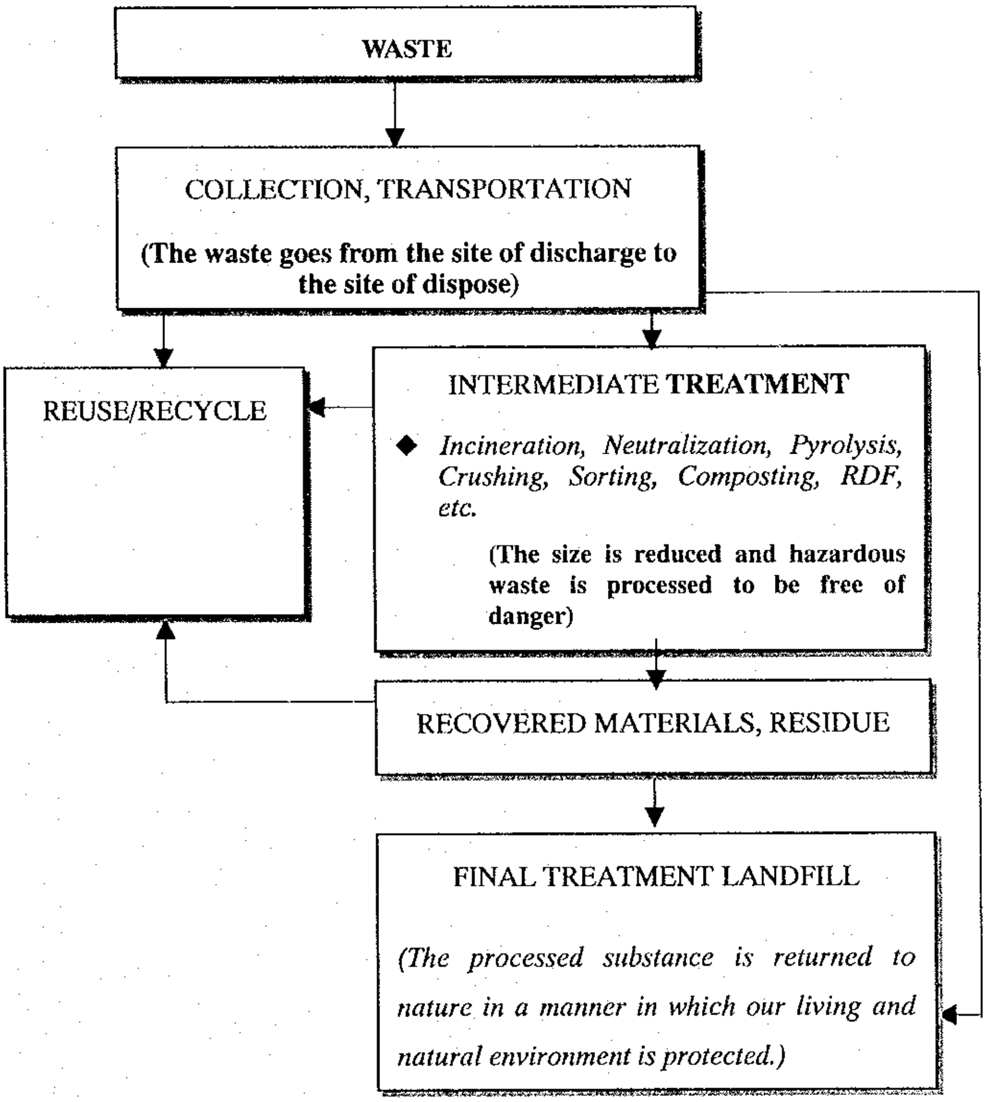


Figure 6.7.1 Overall Waste Treatment Flow

There is a hierarchy of waste management, which begins with waste minimization before proceeding to actual disposal. Therefore, even though there is a wide range of options available and given for the waste disposal, waste management should begin with waste minimization. In other word, waste disposal options, especially for industrial waste management, should follow after the effort of waste minimization. Fundamental concepts of waste disposal options are stabilization and reduction of volume in sanitary conditions after recovering resources for re-use and recycling as much as possible. Figure 6.7.2 shows the hierarchy of waste management or waste minimization strategy.

1) Do not create the waste product in the fist place.

↓

2) If there is a waste product, re-use it.

↓

3) If cannot be re-used, recover or reclaim the primary material for new manufactured products.

↓

4) If primary material recovery is not practicable, recover it for secondary materials or if combustible uses it for fuel.

↓

5) If none of these is practicable proceed to the various waste disposal options choosing the one that has the least environmental impact.

Figure 6.7.2 Hierarchy of Waste Management

Wastes generated in the Hoa Lac and Xuan Mai Urban Areas, which consist of municipal and industrial waste, should be managed in accordance with above waste minimization strategy. Most of these wastes will be disposed of by landfill. Landfill practice should be properly controlled and both landfill gas and leachate collection system should be installed in the site. In Vietnam, collection and disposal of wastes, including non-hazardous industrial waste, is responsibility of central or local agencies. In the case of the Hoa Lac and Xuan Mai Urban Development Project, the landfill site will be selected by the central/local agency inside or adjacent to the project area considering the access to the landfill site, geological and other surrounding conditions. The selected site should comply with the Vietnamese waste disposal/treatment guidelines similar to those listed below so that the environmental impact is minimized. Once the landfill site is selected, wastes generated in the area are collected, transported and treated by the central/local agency or the company such as URENCO authorized and entrusted by this agency.

- All deposits of waste are made in individual layers, which are compacted, on deposition.
- Layers are no more than 2.5 meters in depth.
- Each layer to be covered with earth, or similar, at least 200 to 250 mm thick.
- Waste to be covered within 24 hours.
- No waste to be tipped in water.
- Screens are erected to collect windblown rubbish.
- Precautions are taken to prevent fire and vermin.
- Organic waste is covered with 600 mm of earth.
- Each deposit is kept tidy.
- Adequate component labor be available
- Each layer be allowed to settle before the next layer is started
- Adequate 0 allowed to settle before the next layer is started.
  (Source: JICA/HHTP Project Report)

As for the industrial waste management, especially the treatment of hazardous waste, generated in the area, careful attention should be paid. General industrial wastes produced in the project area are collected, transported and treated after recovering resources for re-use and recycling as can as possible at each factory Treatment method is determined considering the characteristics, quantity, source location, etc. For the general industrial wastes generated from the area, the typical treatment method of sanitary landfilling, site of which will be constructed inside or outside the project area, will be adopted. Administrative entity in the area or the company entrusted by this entity is responsible for all waste collection, transfer, treatment and disposal activities. Practice of treatment and disposal are entrusted to this entity/company. Hazardous wastes are collected by the entity/company after they are sorted by each factory from general waste. This entity/company charge each factory which generates wastes a treatment fee, which includes collection and transportation fees, depending on the quantity and the quality of the wastes. Each entity or the company should construct the treatment facility. The government regulates operations of this entity/company.

(2) Waste management/disposal plan

For formulating a solid waste management/disposal plan in the project area, the following ingredients should be included:

(a) To provide for the safe and efficient collection and disposal of present and future wastes volume.

(b) To be related to the goals and policies of the development area, and to be designed in accordance with regional forecasts of population, employment, and land use.

(c) To be formulated with the help of representatives of central/local governmental bodies which are expected to take action necessary to implement it.

(d) To take into account long-range service requirements, economics of scale in both construction and operation, and alternative uses of resources which are directly or indirectly affected. Related costs and benefits should be defined wherever possible.

(e) To recognize that solid waste collection and disposal are necessary and essential activities to protect public health and welfare and assure healthful, productive, and aesthetically pleasuring surroundings.

(f) To give proper recognition to the important roles played by both public and private sectors in waste management, and to promote intergovernmental and public/private cooperation and coordination in waste management efforts.

(g) To give due consideration to aspects of environmental engineering, environmental health, and water, air, and land pollution control. It must be consistent with central and local environmental control regulations, locate proposed disposal site so as to avoid flood plains and protect groundwater resources, and discourage the introduction of disposal facilities in areas unsuited for that purpose.

(h) To express support for technical solid waste management researches efforts and promotes maximum use of effective and efficient collection and disposal techniques.

(i) To outline appropriate steps necessary to reserve suitable lands for present and future wastes disposal needs, recognizing the potential of land disposal as a means of enhancing distressed lands for subsequent public use.

(j) To seek to maximize recycling of depletable resources, explore and exploit opportunities for waste volume reduction, materials recovery and recycling, and consider economic incentives and/or subsidies as a means of encouraging reuse and recycling.

In addition to above items to be considered for formulating a waste management/disposal plan, there are some problems to be recognized in waste management planning for the project area. The following show these problems to be recognized:

(k) Rising per capita solid waste volumes, increasing population, and intense urban development.

(l) Increasing land costs and decreasing availability of land that is suitable for solid waste disposal and proximate to waste generation sources.

(m) Lack of understanding of solid wastes and their attendant problems.

(n) Apathetic or unfavorable public attitudes toward solid waste management needs and realities.

(o) Lack of adequate records and data regarding solid waste quantities, both by source and type.

(p) Increased costs of solid waste collection and disposal.

(q) Absence of a definitive assignment of responsibilities between the public and the private sectors.

(r) Lagging technology and scarcity of knowledgeable professions in the field of solid waste management.

(s) High processing costs and poor marketability of recycled materials.

(t) Frequent difficulty of compromising operational realities with necessary environmental control.

(u) Difficulties in handling and disposing of hazardous, unique or cumbersome types of wastes.

6.7.2 Solid Waste Disposal Plan

Estimations of the present and future generation rates of solid waste are the basis for the design and planning of solid waste management systems. For this purpose, it is desired to know the average generation rates of waste from various kind of sources. Within the area of Hoa Lac and Xuan Mai, there are varieties of zones, which are characterized by their activities, such as Hi-Tech Park zone, VNU zone, industrial zone, Urban Center zone, residential zone, etc. These zones generate wastes with their activities. However, there is general lack of data on these wastes generation. Area-wide quantitative estimates of wastes are difficult to develop because geographic, economic, and social factors vary among zones. In this study, quantity of wastes generated in the area have been estimated based on the population, number of employees and site area of factories in the area with reference to the data studied in Japan, USA and others.

(1) Sources of Waste Generation

As mentioned before, wastes generated as results of human activities are divided into two categories, one is municipal waste and the other is industrial waste. Wastes generated in the Hoa Lac and Xuan Mai Urban Area also can be classified into these two types of waste. Types of wastes generated within the Hoa Lac and Xuan Mai Urban Area are classified by zones, which are characterized by their activities. The following show waste generation sources and types of waste:

Source	Waste Type
a) Urban Center Area:	Municipal Waste
b) Hoa Lac Hi-Tech Park (HHTP) Area:	Industrial Waste, Municipal Waste
c) VNU Area:	Municipal Waste
d) Phu Cat Industrial Area:	Industrial Waste, Municipal Waste
e) Dong Xuan Area:	Municipal Waste

f) Hoa Lac and Xuan Mai Residential Area: Municipal Waste

(2) Estimate of Waste Generation

1) Urban Center Area

This zone generates variety of aggregate wastes which are categorized as municipal waste such as commercial and institutional wastes, construction and demolition wastes, street sweepings, wastes from recreational area, etc., excluding industrial waste. It is difficult to estimate a quantity of wastes generated in this aggregate commercial and institutional areas because of a lack of data. In this study, a estimate of waste generation in the Urban Center Zone has been carried out based on the number of workers in the zone. The following table shows the result of calculation assuming that the waste generation rate of this area is 1.13 kg per capita per day.

Table 6.7.1 Estimate of Municipal Waste Generation in Urban Center Zone

Year	Phase-1A	Phase-1B	Phase-2
Quantity of Waste Generated (ton/year)	3,320	4,370	11,390

2) Hoa Lac High-tech Park (HHTP) Area

This zone generates both industrial and municipal wastes. For the estimation of quantity of waste generation from the HHTP, the waste generation rate, which is studied in the Report on HHTP study, is available. The average generation rate of industrial waste used for the calculation is 3.9 kg per capita per day. An annual working days of each factory were assumed to be 300 days.

Part of industrial wastes generated is reclaimed for resource recovery or re-use. In advanced countries, the ratios of resource recovery to the total waste generated range normally between about 30% to 40%. In the HHTP thirty five percent (35%) of the waste generated was assumed to be utilized by re-use and/or recycling, etc. Therefore the remaining 65% of the waste including hazardous waste requires proper treatment. Here, the ratio of hazardous waste was assumed to be 15% of these remained wastes, which were not utilized.

As for the municipal waste generated from the HHTP, only wastes generated with the activities of service and construction in the area have been estimated exclusively here.

Other municipal wastes generated in the HHTP such as domestic waste are to be estimated combined with the wastes generated in other areas.

Tables and figures below show the results of estimation.

Table 6.7.2 Estimated Waste Generation in HHTP

Unit: Ton/Year

Year		Phase-1A	Phase-1B	Phase-2
Industrial Waste	Utilized	3,690	6,140	10,240
	Disposed	6,850	11,410	19,010
Municipal Waste		1,900	2,360	2,800

Table 6.7.3 Industrial Waste Treated in HHTP

Unit: Ton/Year

Year	Phase-1A	Phase-1B	Phase-2
General Waste	5,820	9,700	16,160
Hazardous Waste	1,030	1,710	2,850
Industrial Waste Total	6,850	11,410	19,010

3) VNU Area

This zone is characterized mainly by the activities of the University and generates municipal waste. Although waste generation data available in relation with the institutional community such as the VNU zone are very few, EPA has estimated that the aggregate waste from this kind of source generates as a average 0.11 kg per capita per day. In this study, the estimation of waste generation from the VUN zone has been carried out using this figure. In this calculation, an annual working days of the University are assumed to be 180 days. Apart from the activities of the University, there are some other activities such as service and construction in the zone. Wastes generated from these are also considered. The following show the results of the estimation.

Table 6.7.4 Estimated Waste Generation in VNU Are

Unit: Ton/Year

Year	Phase-1A	Phase-1B	Phase-2
Quantity of Waste Generation	640	1,120	1,650

4) Phu Cat Area

When the Hoa Lac and Xuan Mai Urban Project is implemented, variety of industrial sub-sectors will lured in the Phu Cat area. These sub sectors, or factories, will generate industrial wastes according to their activities. Preceding study on the Phu Cat Industrial Park indicates that the sub-sectors which are planned to be introduced in the area are Electronics, Communications, Precision Engineering, Pharmacy and Food, Garments, and so on. It is possible to estimate the amount of industrial wastes generated with their activities based on the waste generation rate by each sub-sector. However, it is difficult to reliably estimate per capita/employee and total wastes. Even within the same industry, the amount of wastes generated varies with the extent of material either recycled or disposed of on site. The generation rates vary locally according to the amount of industrial activity within the given area. All of these factors make evaluation of the impact of industrial wastes on the total solid waste stream rather difficult. In this study, data on waste generation rates studied in USA are used for the estimation of waste generation of each sub-sector. Numerical values of these waste generation rates range from about 2 to 8 ton per employee per year. Furthermore, thirty five percent of total wastes generated are to be utilized by re-use and/or recycling in the same manner as the case of the HHTP. And also the ratio of hazardous waste to total wastes disposed of is assumed to be 15% of them. The following show the results of the calculations.

Table 6.7.5 Estimated Waste Generation in Phu Cat Area

Unit: Ton/Year

Year		Phase-1A	Phase-1B	Phase-2
Industrial Waste	Utilized	7,560	18,890	39,040
	Disposed [1]	14,030	35,080	72,510
Municipal Waste		1,020	1,640	2,040

Note: 1) Including hazardous wastes.

Table 6.7.6 Industrial Waste Treated in HHTP

Unit: Ton/Year

Year	Phase-1A	Phase-1B	Phase-2
General Waste	11,930	29,820	61,630
Hazardous Waste	2,110	5,260	10,880
Industrial Waste Total	14,040	35,080	72,510

5) Don Xuan Area

This area generates municipal wastes, which are resulted from the activities of service and construction in the area in addition to the normal domestic waste. Table and figure below show the estimate of these waste generated.

Table 6.7.7 Estimated Waste Generation in Don Xuan Area [1)]

Unit: Ton/Year

Year	Phase-1A	Phase-1B	Phase-2
Quantity of Waste Generation	2,040	2,600	3,200

Note: [1)] Waste from the residential area is not included.

6) Hoa Lac and Xuan Mai Residential Zones

This area means whole residential area in Hoa Lac and Xuan Mai, and generates a domestic waste. Total amount of domestic waste generated in the area has been estimated here based on the population. In general, the average generation rate of domestic waste is considered as between 0.5 to 1.0 kg per capita per day. Considering a tendency of an universal increase of waste generation rate with year, estimation has been carried out using the figures shown below at each year.

Table 6.7.8 Domestic Waste Generation Rate

Unit: Ton/Year

Year	1996	Phase-1A	Phase-1B	Phase-2
Waste Generation Rate (kg/capita/day)	0.5	0.7	0.8	1.0

The following show the result of estimation.

Table 6.7.9 Estimated Municipal Waste Generation from Residential Area

Unit: Ton/Year

Year	1996	Phase-1A	Phase-1B	Phase-2
Hoa Lac	8,030	34,490	59,860	146,000
Xuan Mai	6,390	11,500	16,060	36,500
Total	14,420	45,990	75,920	182,500

7) Summary of Waste Generation in Hoa Lac & Xuan Mai

Wastes, both municipal and industrial, generated in the whole area of Hoa Lac and Xuan Mai are summarized as follows:

Table 6.7.10 Estimated Total Waste Generation in Hoa Lac and Xuan Mai Area

Unit: Ton/Year

Year			1996	Phase-1A	Phase-1B	Phase-2
Municipal Waste			14,420	54,910	88,010	203,580
Industrial Waste	**Utilized**		-	11,250	25,030	49,280
	Waste disposal of	**General**	-	17,750	39,520	77,790
		Hazardous	-	3,140	6,970	13,730
		Total	-	20,890	46,490	91,520

(3) Solid Waste Management Costs

As mentioned before, collection and disposal of municipal waste is responsibility of the central or local agencies. Municipal waste generated in the Hoa Lac and Xuan Mai Urban Area will be collected, transported and disposed of by the central/local agency or private firm entrusted by this agency. Concerning general industrial wastes, these wastes generated in the Project area are collected, transported and treated after recovering resources for re-use and recycling as much as possible at each factory. There are varieties of options for the treatment of wastes. In Hoa Lac and Xuan Mai Urban Area, municipal and general industrial waste will be treated by sanitary landfill, which is the typical treatment method and is strictly controlled to minimize adverse impacts to the environment. The landfill site will be selected by the central/local agency inside or adjacent to the project area considering the access to the landfill site, geological and other conditions.

In general, roughly 75 to 80% of waste management expenditure for municipal and industrial is attributable to collection costs, with the remainder devoted to disposal costs. Although collection costs vary widely and can be much higher in the advanced country such as Japan and USA, these of average costs are considered to be $10 to $20 per ton. Disposal costs also generally range from $1 to $5 per ton for sanitary landfill.

The following shows the result of costs estimation of wastes treatment in relation with municipal and general industrial wastes. In this table, total waste disposal cost, including collection, transport and disposal, is assumed to be $17 per ton. Costs of land acquisition and site construction are excluded.

Table 6.7.11 Estimation of Waste Disposal Cost

Year	Phase-1A	Phase-1B	Phase-2
Municipal Waste (Ton/Yr.)	54,910	88,010	203,580
General Industrial Waste (Ton/Yr.)	17,750	39,520	77,790
Total Waste Disposed of (Ton/Yr.)	72,660	127,530	281,370
Waste Disposal Cost (1,000$/Yr.)	1,240	2,170	4,780

Above table indicates that total amount of waste generated to be disposed of from 2005 to 2020 is 2,545,000 tons. Assuming that wastes landfill are compressed into the density of 1 ton per 1 cubic meter, the area of landfill site required throughout from 2005 to 2020 is 510,000 m2, or 51 ha. Here the thickness of the landfill layer is assumed to be 5 meters.

Conditions to be included for the location of landfill site are:

(a) the place not far from the center of the project area,

(b) the place easy to access,

(c) the place not close to the residential area,

(d) the place where no possibility of polluting surface and ground water, and

(e) the place where small influence of the wind on the area.

Considering the above conditions and topographical conditions around the area, the location of proposed landfill site is selected at :

- southern side of NR 6,
- western side of NR 21A, and
- northern foot of the Mount Bui or other appropriate near place where meets above conditions taken:

CHAPTER 7

IMPLEMENTATION PLAN AND EVALUATION OF THE HOA LAC AND XUAN MAI URBAN DEVELOPMENT

CHAPTER 7 Implementation Plan and Evaluation of the Hoa Lac and Xuan Mai Urban Development

7.1 Summary of Development Cost Estimate

The development cost is estimated based on the conditions listed below. The cost is the total cost for the development of infrastructure and facilities regardless of funding sources (inclusive of public and private frunding). However, the cost for construction of the Lang-Hoa Lac Highway and possible future Mass Raiway Transit (MRT) is not included in the external cost.

(a) The cost is based on the price prevaling in 1998;

(b) The exchange rate for conversion of VND to US$ is that US$ 1.00 = VND 13,900;

(c) The cost includes all the related costs, including those for engineering, temporary works, construction, and physical contingency;

(d) The cost estimation does not include land acquisition cost, nor the cost for resettlement of inhabitants;

(e) The cost for industrial development does not include the cost for production plants and equipment in factories; and

(f) The cost does not include any taxes, levies, and charges.

Table 7.1.1 shows the cost summary for the VNU Relocation, while Table 7.1.2 shows the cost summary for the HHTP Development and the Phu Cat Area Development. Table 7.1.3 and Table 7.1.4 show the cost summaries for the Housing Development and for the Urban Center Development, respectively. Meanwhile, Table 7.1.5 provides a summary of the total cost for the Hoa Lac and Xuan Mai Areas Urban Development.

Table 7.1.1 Cost Summary for the VNU Relocation

Unit: US$ x 1,000

		Phase 1A	Phase 1B	Phase 2	Total
(1)	Land Preparation	1,354	3,526		4,880
	Landscaping (inc. water drainage)	4,095	11,352		15,447
	Sub-total	**5,449**	**14,878**		**20,327**
(2)	**Building Facilities for Study/Research**				
	Natural science Field	14,753	6,161	20,219	41,133
	Social science Field	10,775	3,561	5,946	20,282
	Pedagogy/Foreign Language Field	15,439	2,431	2,385	20,255
	Healthcare and Social Service Field		6,110	15,366	21,476
	Sub-total	**40,967**	**18,263**	**43,916**	**103,146**
(3)	**Building Facilities for Administration**				
	Natural science Field	1,702	711	2,332	4,745
	Social science Field	1,243	411	686	2,340
	Pedagogy/Foreign Language Field	1,781	281	275	2,337
	Healthcare and Social Service Field		705	1,068	1,773
	Sub-total	**4,726**	**2,108**	**4,361**	**11,195**
(4)	**Machinery/Equipment**				
	Natural science Field	78,788	33,092	108,323	220,203
	Social science Field	2,201	522	918	3,641
	Pedagogy/Foreign Language Field	9,073	491	1,140	10,704
	Healthcare and Social Service Field		62,425	72,875	135,300
	Sub-total	**90,062**	**96,530**	**183,256**	**369,848**
(5)	**VNU HQs Building**	1,005	338	656	**1,999**
(6)	**Buildings of Research Institutes/Centers**	4,290	3,060	4,590	**11,940**
(7)	**Center Facilities**	5,472	2,910	4,840	**13,222**
(8)	**Hospital**		12,000	12,000	**24,000**
(9)	**Dormitory**	48,972	22,441	38,421	**109,834**
(10)	**Guest House**	1,825	2,316	2,112	**6,253**
(11)	**Community Centers**	9,800	1,560	3,120	**14,480**
(12)	**Sports/Athletic Facilities**	2,000	2,000	4,000	**8,000**
	Total	**214,568**	**178,404**	**301,272**	**694,244**

Table 7.1.2 Cost Summary for the HHTP Development and the Phu Cat Area Development

Unit: US$ x 1,000

		Phase 1A	Phase 1B	Phase 2	Total
(1)	Land Preparation	9,120	4,170	7,080	20,370
	Landscaping	16,440	7,500	12,720	36,660
	Sub-total	**25,560**	**11,670**	**19,800**	**57,030**
(2)	Research and development area	25,740	91,740		117,480
	Software area	34,380	60,505		94,886
	Central area	11,288	12,388		23,676
	High technology industrial area	667,700	1,651,100		2,318,800
	Urban business area	22,550	46,750		69,300
	High class housing area	18,508	32,148		50,655
	New district center	38,896	102,760		141,656
	Recreation area	10,560	30,228		40,788
	Sub-total of Factories	**829,622**	**2,027,619**		2,857,241
	Total	**855,182**	**2,039,289**	19,800	**2,914,271**

Unit: US$ x 1,000

		Phase 1A	Phase 1B	Phase 2	Total
(1)	**PHU CAT**	**39,468**	13,017	99,378	266,634
	Land Preparation	2,040	510	5,100	7,650
	Landscaping	1,428	357	3,570	5,355
	Sub-total	3,468	867	8,670	13,005
	Industrial development	28,800	8,100	76,500	113,400
	Warehouse	2,700	900	5,738	9,338
	Whole sale market	900		1,900	2,800
	Truck terminal	1,800		3,285	5,085
	Administration center	1,800		3,285	5,085
	Vocational training center		3,150		
	Sub-total of Factories	**36,000**	**12,150**	**90,708**	**138,858**
(2)	**XUAN MAI**	**21,293**	**12,796**	93,687	**127,776**
	Land Preparation	1,275	765	5,610	7,650
	Landscaping	893	536	3,927	5,356
	Sub-total	2,168	1,301	9,537	13,006
	Factories (building)	19,125	11,495	84,150	114,770
	Total	60,761	25,813	193,065	394,410

Table 7.1.3 Cost Summary for the Housing Development

Unit: US$ x 1,000

Public/Community Facilities		Phase 1A	Phase 1B	Phase 2	Total
(1)	**Land Preparation/Landscaping**				
	Land Preparation	7,443	6,522	35,616	49,581
	Landscaping	6,699	5,870	22,334	34,903
	Hoa Lac Sub-total	14,142	12,392	57,950	84,484
	Land Preparation	1,215	1,095	6,378	8,688
	Landscaping	1,094	986	5,740	7,820
	Xuan Mai Sub-total	2,309	2,081	12,118	16,508
	Sub-total	**16,451**	**14,473**	**70,068**	**100,992**
(2)	**Educational Facilities**				
	Nursery School	5,280	4,128	16,192	25,600
	Primary School	13,120	9,840	36,080	59,040
	Secondary School	12,288	9,216	33,792	55,296
	High School	3,210	3,210	12,840	19,260
	Sub-total	**33,898**	**26,394**	**98,904**	**159,196**
(3)	**Medical/Healthcare Facilities**				
	Public health station	1,680	1,260	4,620	7,560
	Clinical Examination Center	2,400	1,800	6,600	10,800
	Policlinic	5,000	5,000	20,000	30,000
	Maternity	600	600	1,800	3,000
	Sub-total	**9,680**	**8,660**	**33,020**	**51,360**
(4)	**HOUSING by Income Level**				
	HIGH INCOME				
	Detached/Semi detached House	7,400	6,400	37,600	51,400
	Row house	13,200	11,400	65,700	90,300
	MIDDLE INCOME				
	Condominium (High-rise)	35,280	32,275	204,660	272,215
	LOW INCOME				
	Apartment (walk-up/4~5F)	51,025	55,536	198,952	305,513
	Sub-total	**99,505**	**99,211**	**469,312**	**668,028**
	Total	**159,534**	**148,738**	**671,304**	**979,576**

Table 7.1.4 Cost Summary for the Urban Center Development

Unit: US$ x 1,000

		Phase 1A	Phase 1B	Phase 2	Total
(1)	**VNU Area**				
	Land Preparation	377	411	145	933
	Landscaping	679	740	261	1,680
	Sub-total of Land Preparation/	1,056	1,151	406	2,613
	Laboratory	6,000	-	-	6,000
	Museum	7,000	-	-	7,000
	Information center	-	6,000	-	6,000
	Rental laboratory	-	3,000	3,000	6,000
	Information center	3,000	3,000	6,000	12,000
	Office	4,560	1,440	3,060	9,060
	History museum	-	5,250	-	5,250
	Art museum	-	3,500	-	3,500
	Theater	-	10,000	-	10,000
	Concert hall	-	-	5,000	5,000
	Cultural center	3,000	-	-	3,000
	Exhibition hall	-	1,500	-	1,500
	Commercial	600	200	400	1,200
	Other	500	500	500	1,500
	Sub-total of Building Facilities	24,660	34,390	17,960	77,010
	Total	25,716	35,541	18,366	79,623
(2)	**HHTP Area**				
	Land Preparation	177	82	821	1,080
	Landscaping	211	148	1,478	1,837
	Sub-total of Land Preparation/	388	230	2,299	2,917
	Convention hall	-	-	7,500	7,500
	Exhibition hall	-	-	15,000	15,000
	Event hall	-	-	4,500	4,500
	Convention hotel	-	-	5,000	5,000
	World trade center	-	-	15,000	15,000
	Office	10,800	7,200	10,800	28,800
	Commercial	140	80	160	380
	Other	500	500	500	1,500
	Sub-total of Building Facilities	11,440	7,780	58,460	77,680
	Total	11,828	8,010	60,759	80,597
(3)	**Dong Xuan Area**				
	Land Preparation	1,201	1,831	2,300	5,332
	Landscaping	2,162	3,296	4,140	9,598
	Sub-total of Land Preparation/	3,363	5,127	6,440	14,930
	Civic center	10,800	20,400	28,800	60,000
	Commercial	5,400	2,400	7,200	15,000
	Restaurant	2,430	1,080	3,240	6,750
	Open market	-	-	-	-
	Financial office	5,400	10,200	44,400	60,000
	City hotel	2,500	2,500	5,000	10,000
	Cultural school	2,000	1,000	3,000	6,000
	Library	-	-	-	-
	Exhibition center	1,000	-	1,000	2,000
	Culture center	-	-	1,500	1,500
	Theater	5,000	2,500	7,500	15,000
	Sport club	1,500	-	1,500	3,000
	Amusement center	1,000	-	1,000	2,000
	Polyclinic	2,000	-	2,000	4,000
	Clinic	1,200	-	1,200	2,400
	Other	1,000	1,000	1,000	3,000
	Sub-total of Building Facilities	41,230	41,080	108,340	190,650
	Total	44,593	46,207	114,780	193,856
(4)	**Phu Cat Area**				
	Land Preparation	179	824	142	1,145
	Landscaping	322	1,483	256	2,061
	Sub-total of Land Preparation/	501	2,307	398	3,206
	Theme park	-	40,000	-	40,000
	Amusement park	1,500	-	2,000	3,500
	Circus	500	-	-	500
	Zoo, botanical garden	-	5,000	-	5,000
	Theater	3,500	1,750	5,250	10,500
	Bowling center	1,000	500	1,500	3,000
	Commercial	60	80	320	460
	Other	500	500	500	1,500
	Sub-total of Building Facilities	7,060	47,830	9,570	64,460
	Total	7,561	50,137	9,968	67,666
	G. Total	89,698	139,895	203,873	433,466

Table 7.1.5 Summary of the Total Cost for the Hoa Lac and Xuan Mai Urban Development Project

	Phase 1A	Phase 1B	Phase 2	Total
1 VNU	214,568	178,404	301,272	694,244
Land Preparation/Landscaping	5,449	14,878	-	20,327
Equipment and Machinery	90,062	96,530	183,256	369,848
Building Facilities and Others	119,057	66,996	118,016	304,069
2 HHTP	855,182	2,039,289	19,800	2,914,271
Land Preparation/Landscaping	25,560	11,670	19,800	57,030
Center/Factories Building	829,622	2,027,619	-	2,857,241
3 Phu Cat Industrial Developments	39,468	13,017	99,378	151,863
Land Preparation/Landscaping	3,468	867	8,670	13,005
Center/Factories Building	36,000	12,150	90,708	138,858
4 Hoa Lac Urban Center Development	89,698	139,895	203,873	421,742
VNU Area	25,716	35,541	18,366	79,623
HHTP Area	11,828	8,010	60,759	80,597
Dong Xuan Area	44,593	46,207	114,780	193,856
Phu Cat Area	7,561	50,137	9,968	67,666
5 Xuan Mai Industrial Development	21,293	12,796	93,687	127,776
Land Preparation/Landscaping	2,168	1,301	9,537	13,006
Center/Factories Building	19,125	11,495	84,150	114,770
6 Housing and Public/Communities Facilities	166,934	155,138	708,904	1,030,976
Land Preparation/Landscaping	16,451	14,473	70,068	100,992
Educational Facilities	33,898	26,394	98,904	159,196
Medical and Health Care Facilities	9,680	8,660	33,020	51,360
Housing	106,905	105,611	506,912	719,428
Detached/Semi-detached Type	7,400	6,400	37,600	51,400
Row House Type	13,200	11,400	65,700	90,300
Condominium Type	35,280	32,275	204,660	272,215
Walk-up Apartment (5F)	51,025	55,536	198,952	305,513
6 Road and Transportation Facilities	131,684	105,990	217,099	454,773
Hoa Lac Area (within the Urbanized Area)	103,640	81,131	154,738	339,509
Regional Road Dev't/Improvement	27,533	11,250	32,980	71,763
Transportation Terminal	3,750	3,000	3,000	9,750
Inner Arterial/Distributor Road	72,357	66,881	118,758	257,996
Xuan Mai Area (within the Urbanized Area)	13,004	15,019	46,761	74,784
Regional Road Dev't/Improvement	4,050	-	26,595	30,645
Inner Arterial/Distributor Road	8,954	15,019	20,166	44,139
Bridges (within the Both Urbanized Area)	15,040	9,840	15,600	40,480
7 Infrastructure	359,690	232,210	402,040	993,940
Water Supply	132,800	74,400	24,800	232,000
External Transmission from Da River	86,800	47,400	-	134,200
Inner Distribution Main Pipe	7,300	4,600	2,400	14,300
Minor Distribution/Supply Pipe	38,700	22,400	22,400	83,500
Electric Power Supply	121,440	80,740	101,630	303,810
External 220KV Transmission Line	13,350	7,030	-	20,380
Substation : 220/110KV	17,320	10,010	10,010	37,340
Inner 110KV Transmission Line	3,980	2,600	1,630	8,210
Substation : 110/22KV	19,280	16,560	18,430	54,270
22KV Distribution Network	67,510	44,540	71,560	183,610
Telecommunication	36,000	29,000	135,000	200,000
Sewerage Disposal	63,250	37,220	92,810	193,280
Main and Collection Pipelines	11,050	9,620	34,610	55,280
Treatment Facilities	52,200	27,600	58,200	138,000
Solid Waste Disposal	6,200	10,850	47,800	64,850
8 Total Cost	1,878,517	2,876,739	2,046,053	6,789,585

- Land preparation & landscaping include the cost for site clearance, earth work, site drainage, park & open space, pedestrian paths, and riverside open space construction.
- HHTP and industrial development exclude the cost for equipment and machinery to be installed by locators.
- Regional roads exclude off-site regional roads, and the future mass transit development cost is excluded.
- Water supply systems include the cost for intake/purification facilities, pipelines, and reservoir in Hoa Lac.
- External 220KV transmission lines include the cost for additional supply lines from Hoa Binh to Xuan Mai.