6. SEWERAGE SYSTEM

6.1 Outline of Original Sector Plan

(1) Sewage Collection Area and Basic Collection System

In the original M/P, a common sewerage system which covers both HHTP and VNUH area was planned. The separated collection system was adopted because it is more advantageous in terms of water environment preservation than a combined sewerage system.

(2) Sewage Volume

Sewage volume was projected based on the total water demand as follows.

Table 6.1-1 Projection of Sewage Volume in the Original M/P

Area	Volume	Remarks
Daily Average Sewage (DAS)	68,000 m^3/day	=Daily Average Water Demand
Daily Maximum Sewage	97,920 m^3/day	=DAS x (1+ groundwater infiltration ratio, 20%)
Total (Daily Average Sewage)	10,200 m^3/hour	=DMS x (hourly peak factor, 2.5) x 1/24

Source: JICA Study Team

(3) Outline of Sewerage System

The sewerage system in the original M/P, which was to be shared by HHTP and VNUH, consisted of a sewage collection system, sewage treatment plant, treated water discharge system and water reclamation plant. Main specifications of those sewerage facilities are shown in Table 6.1-2.

Table 6.1-2 Main Specifications for Facilities in the Original M/P

Component System	Facilities and Specifications
1. Main Sewage Collection System	Total capacity: Maximum 10,420 m^3/hr -Main collection pipes (HCP 200-1800mm x length 18km)
2. Sewage Treatment Plant	Total production capacity: 100,000 m^3/day (2,000 x 5 trains) -Grit chambers and screens -Oxidation ditches -Sedimentation tanks -Disinfection systems -Sludge dehydration systems -Power substation -Administration and chemical handing room
3. Water Reclamation Plant	Total production capacity: 10,000 m^3/day -Rapid sand filters -Reclaimed water reservoir
4. Treated Water Discharge System	Total capacity: 100,000 m^3/day -Water quality monitoring equipment -Water discharge pipes and outfall -1,700 m^3 x 1 unit
5. Zonal sewage collection System *1	-Collection pipes (HCP: 200-600mm x length 21,160m, VP: 150mm x 5,840m) -Relay pump station (1 station)

*1 Zonal sewage collection system was planned only for phase-1 in the Feasibility Study
Source: JICA Study Team

(4) Plan of Sewage Treatment Plant

1) Capacity and Development Plan

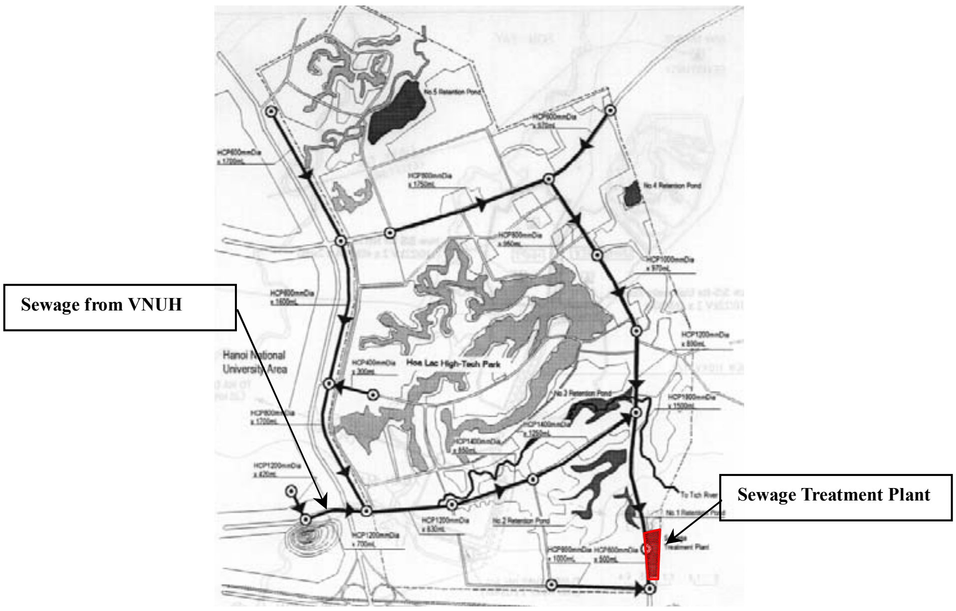
A Sewage Treatment Plant was to be developed stepwise in line with the sewage discharge volume in the respective phases as follows.

Table 6.1-3 Sewage Treatment Plant Development Plan in the Original M/P

Items	Phase		
	2005	2010	2020
Daily Maximum Sewage	33,100 m^3/day	62,100 m^3/day	97,920 m^3/day
Water Treatment Capacity	20,000 x 2 trains (Total 40,000)	20,000 x 4 trains (Total 80,000)	20,000 x 5 trains (Total 100,000)

Source: JICA Study Team

Location of the Sewage treatment plant in the original M/P is shown is Figure 6.1-1. Treated water was to be discharged into the Tich River via the tributary running through the HHTP. In order to reduce water consumption in the area, 10 % of the treated water was planned to be reused for irrigation for green keeping and other purposes, after being treated in a water reclamation system.



Source: Master Plan of Hoa Lac High-Tech Park in 1998, JICA Study Team

Figure 6.1-1 Collection System and Location of Sewage Treatment Plant in the Original M/P

2) Water Quality

The sewage treatment plant was planned to treat sewage to meet the Level-B effluent limitations specified by the Vietnamese Standard TCVN 5942-1995, i.e. less than 50 mg/l of BOD and less than 100 mg/l of SS, which is applied when the water is discharged to water bodies being used for navigation and irrigation purposes.

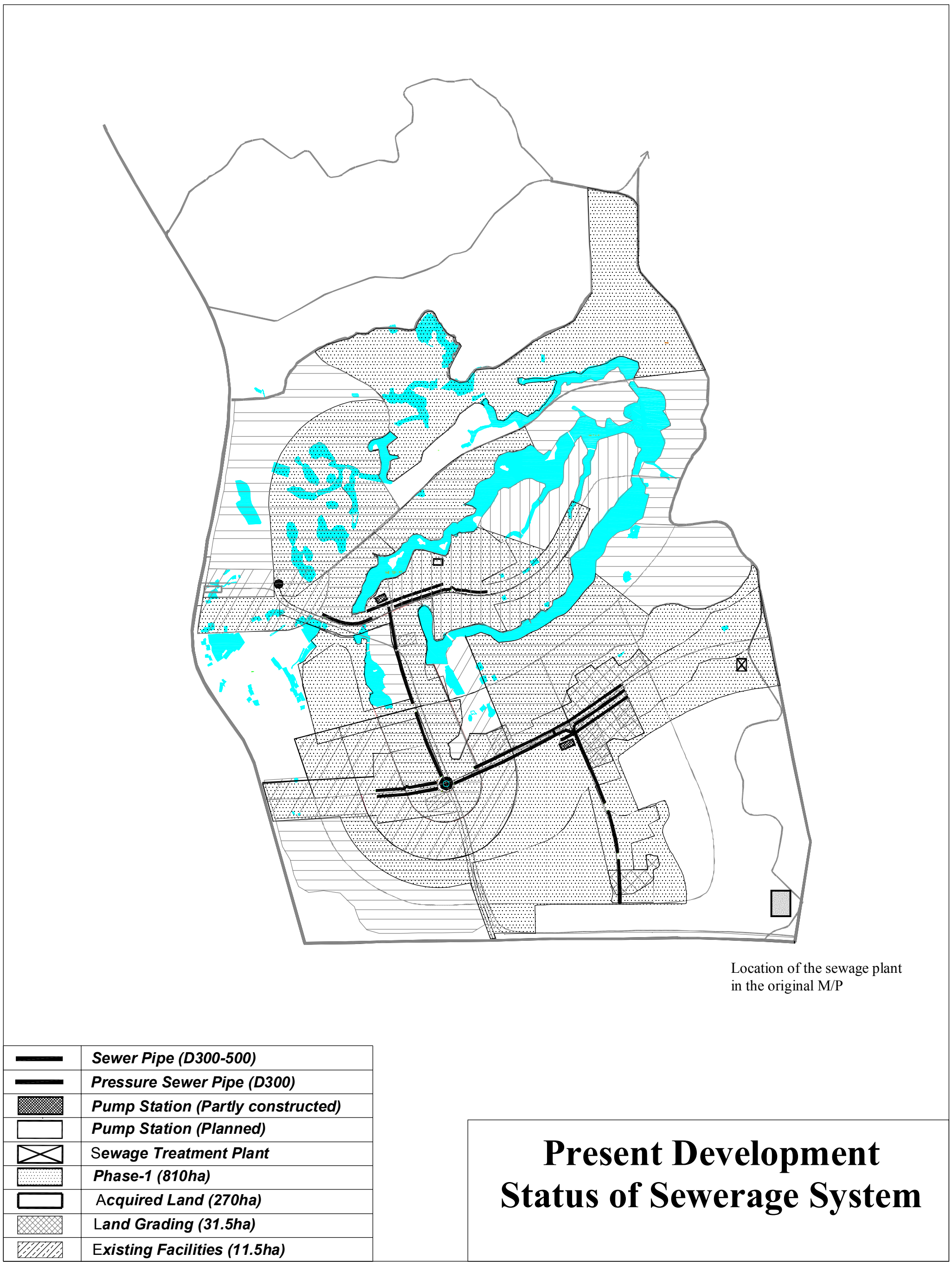
In the event that the sewage contains hazardous or toxic substances with higher concentrations than the specified limitation, tenant enterprises were to be obligated to provide their own pretreatment systems.

6.2 Present Condition

6.2.1 Current Development Progress

(1) Sewerage system

Sewer pipes have been installed in line with the development of the internal road network and a sewage treatment plant (6,000m^3/day) is under construction and will be completed by July 2008. Location of the sewage treatment plant and present development status of the sewer pipes are shown in Figure 6.2-1. Three pump stations are planned and two of them have been partly constructed. Treated effluent from the plant will be discharged into the Tich River.



Source: JICA Study Team

Figure 6.2-1 Present Sewerage Network

Source: JICA Study Team

Construction of Water Treatment Plant in HHTP

(2) Difference between the Original M/P and the Present Plan

1) Collection Area and Capacity

The sewerage system which has been developed is aimed at only 200 ha of stage-1. Therefore, capacities of sewer pipe, pump stations and sewage treatment plan are scaled down.

2) Location of Sewage Treatment Plant

Location of the sewage treatment plant has been changed as shown in Figure 6.2-1.

3) Treatment Process and Discharge Water Quality of Sewage Treatment Plant

In the original M/P, the quality of water discharged from the sewage treatment plant was planned to meet the Class-B effluent limitations specified by the Vietnamese Standard TCVN 5942-1995. However, the sewage treatment plant has been designed by HHTP-MB to meet the Class-A limitations, which are more strict than Class-B, because there are some people using the water of Tich River for use in their homes.

Effluent standards for industrial sewage as specified in TCVN 5945-1995 are shown in Table 6.2-1.

(3) Treatment of Sewage in the Existing Facilities in HHTP

The existing facilities such as the Start-UP Center and Internet Gate are equipped with septic tanks. NOBLE, the existing manufacture has constructed its own treatment plant.

6.2.2 Related Project

There are no related projects for the sewerage system near HHTP.

Table 6.2-1 Effluent Standards for Industrial Sewage (TCVN 5945-1995)

Applied in the sewage treatment plant design (column A) — Applied in the original MP (column B)

no	Parameters and substances	Unit	Limitation Values		
			A	B	C
1	Temperature	°C	40	40	45
2	pH value		6 - 9	5.5 - 9	5 - 9
3	BOD_5 (20°C)	mg/l	20	50	100
4	COD	mg/l	50	100	400
5	Suspended solids	mg/l	50	100	200
6	Arsenic	mg/l	0.05	0.1	0.5
7	Cadmium	mg/l	0.01	0.02	0.5
8	Lead	mg/l	0.1	0.5	1
9	Residual chlorine	mg/l	1	2	2
10	Chromium (VI)	mg/l	0.05	0.1	0.5
11	Chromium (III)	mg/l	0.2	1	2
12	Mineral oil and fat	mg/l	not detectable	1	5
13	Animal-vegetable fat and oil	mg/l	5	10	30
14	Copper	mg/l	0.2	1	5
15	Zinc	mg/l	1	2	5
16	Manganese	mg/l	0.2	1	5
17	Nickel	mg/l	0.2	1	2
18	Organic phosphorous	mg/l	0.2	0.5	1
19	Total phosphorous	mg/l	4	6	8
20	Iron	mg/l	1	5	10
21	Tetrachlorethylene	mg/l	0.02	0.1	0.1
22	Tin	mg/l	0.2	1	5
23	Mercury	mg/l	0.005	0.005	0.01
24	Total nitrogen	mg/l	30	60	60
25	Trichlorethylene	mg/l	0.05	0.3	0.3
26	Ammonia (as N)	mg/l	0.1	1	10
27	Fluoride	mg/l	1	2	5
28	Phenol	mg/l	0.001	0.05	1
29	Sulfide	mg/l	0.2	0.5	1
30	Cyanide	mg/l	0.05	0.1	0.2
31	Coliform	MPN/100ml	5000	10000	-
32	Gross α activity	Bg/l	0.1	0.1	-
33	Gross β activity	Bg/l	1	1	-

Notes :

The column A : discharged into the water bodies being used for sources of domestic water supply.
The column B : To be discharged only into the water bodies being used for navigation, irrigation purposes or for bathing, aquatic breeding and cultivation, etc.
The column C : not be discharged into surroundings.

Source: Master Plan of Hoa Lac High-Tech Park in 1998, JICA Study Team

6.3 Update of Sector Plan

6.3.1 Sector Development Missions, Strategies and Goals

Missions, strategy and goals for sewerage sector are stated as below.

Table 6.3-1 Missions, Strategies and Goals for Sewerage Sector

Missions	To create a sanitary urban environment which enables people in HHTP to work creatively and live healthy lives. To protect the natural environment surrounding HHTP from the impact of various activities in HHTP.
Strategies	To plan a collection system with sufficient capacity that can remove sewage efficiently and reliably from the urban area in order to maintain a sanitary living and working environment. To plan a strong and durable water treatment system that can ensure proper discharge water quality in order to conserve the environment. To plan a simple system that can facilitate the operation and minimize the maintenance work in order to secure the reliability of the entire sewerage system.
Goals	To complete the development of sewerage system of the HHTP by 2012 (for Phase-1) and by 2020 (for Phase-2).

As indicated in Section 6.2, there are no sewerage projects near HHTP. Therefore, a new sewerage system for HHTP should be developed by HHTP.

The strategies to achieve the development goals in this M/P are as follows.

6.3.2 Planning Framework

(1) Sewage Collection Area

In the Original M/P, the sewerage system including sewage collection system and sewage treatment plant was planned to be used for both HHTP and VNUH from the view point of economical infrastructural development. However, since the original M/P, HHTP and VNUH have developed their infrastructure independently. Therefore, in this M/P, the sewage collection area is confined to HHTP area.

(2) Sewage Volume

1) Daily Maximum Sewage

Daily maximum sewage volume is estimated as shown in Table 6.3-2, which is based on the water demand. Sewerage generation factor, which is defined as 90 %, is determined by the assumption that 10 % of the consumed water will be used for watering and cleaning including public purposes, etc. and will not be discharged into the sewerage system. Daily maximum peak factor (1.3 for phase-1 and 1.2 for phase-2) is consistent with those for water consumption in each phase.

2) Hourly Maximum Sewage

Hourly maximum sewage volume is an important figure to be used for design of the collection system including sewer pipes and pump stations. Hourly maximum sewage volume by functional zone in each phase is shown in Table 6.3-3. The hourly maximum factor is consistent with that of water consumption in each phase.

Table 6.3-2 Sewage Volume in HHTP

No.	Land Use	Phase-1 (2012) Average Water Demand (m^3/day)	Phase-1 (2012) Maximum Sewage Factor (%)	Phase-1 (2012) Sewage Volume (m^3/day)	Phase-2 (2020) Average Water Demand (m^3/day)	Phase-2 (2020) Maximum Sewage Factor (%)	Phase-2 (2020) Sewage Volume (m^3/day)
1.	Software Park	140	1.10	150	290	1.08	310
2.	Research and development (R&D Zone)	1,540	1.10	1,690	2,860	1.08	3,090
3.	High-tech Industrial Zone	6,300	1.10	6,930	15,300	1.08	16,520
4.	Education and Training Zone	440	1.10	480	6,040	1.08	6,520
5.	Center of Hgh-Tech City	640	1.10	700	2,530	1.08	2,730
6.	Mixed Use Zone	1,910	1.10	2,100	3,600	1.08	3,890
7.	High Class Residential (R&D Zone, Amenity Zone)	0	1.10	0	450	1.08	490
8.	Residential Zone	570	1.10	630	2,700	1.08	2,920
9.	Housing Complex	0	1.10	0	1,440	1.08	1,560
10.	Reserved Area	0	1.10	0	8,100	1.08	8,750
11.	Golf Course (Amenity Zone)	10	1.10	10	10	1.08	10
12.	Amusement Zone	790	1.10	870	1,500	1.08	1,620
Daily Maximum Waste Water Quantity (m^3/day)		12,300	-	13,600	44,800	-	48,400

*1 A = B x C
A: Maximum Sewage Factor
B: Sewage Generation Factor (= 0.90)
C: Daily Maximum Peak Factor (Phase-1: 1.3, Phase-2: 1.2)

Source: JICA Study Team

Table 6.3-3 Hourly Maximum Sewage

[Phase-1]

No.	Land Use	Phase-1 (2012) Net Area (ha)	Gross Area *1 (ha)	Daily Maximum Sewage (m^3/day)	Hourly Maximum Sewage (m^3/hour)	Unit Hourly Maximum Sewage (m^3/ha/day)	Unit Hourly Maximum Sewage (l/ha/s)
1.	Software Park	45	54	150	8.3	2.778	0.042
2.	Research and development (R&D Zone)	70	83	1,690	93.0	20.361	0.311
3.	High-tech Industrial Zone	140	167	6,930	381.2	41.497	0.634
4.	Education and Training Zone	55	65	480	26.4	7.385	0.113
5.	Center of Hgh-Tech City	40	48	700	38.5	14.583	0.223
6.	Mixed Use Zone	75	89	2,100	115.5	23.596	0.360
7.	High Class Residential (R&D Zone, Amenity Zone)	0	0	0	0.0	#DIV/0!	#DIV/0!
8.	Residential Zone	15	18	630	34.7	35.000	0.535
9.	Housing Complex	0	0	0	0.0	0.000	0.000
10.	Reserved Area	0	0	0	0.0	0.000	0.000
11.	Golf Course (Amenity Zone)	100	119	10	0.6	0.084	0.001
12.	Amusement Zone	20	24	870	47.9	36.250	0.554

*1 Gross Area: Area Includes Infrastructure area =Net Area/0.84

[Phase-2]

No.	Land Use	Phase-2 (20120) Net Area (ha)	Gross Area *1 (ha)	Daily Maximum Sewage (m^3/day)	Hourly Maximum Sewage (m^3/hour)	Unit Hourly Maximum Sewage (m^3/ha/day)	Unit Hourly Maximum Sewage (l/ha/s)
1.	Software Park	75	89	310	16.3	3.48	0.051
2.	Research and development (R&D Zone)	130	155	3,090	162.2	19.94	0.291
3.	High-tech Industrial Zone	340	405	16,520	867.3	40.79	0.595
4.	Education and Training Zone	95	113	6,520	342.3	57.70	0.841
5.	Center of Hgh-Tech City	50	60	2,730	143.3	45.50	0.664
6.	Mixed Use Zone	100	119	3,890	204.2	32.69	0.477
7.	High Class Residential (R&D Zone, Amenity Zone)	25	30	490	25.7	16.33	0.238
8.	Residential Zone	50	60	2,920	153.3	48.67	0.710
9.	Housing Complex	20	24	1,560	81.9	65.00	0.948
10.	Reserved Area	180	214	8,750	459.4	40.89	0.596
11.	Golf Course (Amenity Zone)	100	119	10	0.5	0.08	0.001
12.	Amusement Zone	60	71	1,620	85.1	22.82	0.333

Source: JICA Study Team

*1 Gross Area: Area Includes Infrastructure area =Net Area/0.84

(3) Discharge Water Quality

The latest standards for effluent of industrial sewage, TCVN 5945-2005 are shown in Table 6.3-4. In the original M/P, Level-B of the former standard TCVN 5945-1995 was applied. However, in this M/P Class-A of TCVN 5945-2005 is applied, due to the fact that the water of Tich River where the treated water will be discharged is used for living purposes.

Table 6.3-4 Effluent Standards for Industrial Sewage (TCVN 5945-2005)

	Parameter	Unit	Limitation		
			A	B	C
1	Temperature	°C	40	40	45
2	pH	-	6 - 9	5.5 - 9	5 – 9
3	Odor	-			
4	Color	-	20	50	-
5	BOD_5	mg/l	30	50	100
6	COD	mg/l	50	80	400
7	Suspended solids	mg/l	50	100	200
8	Arsenic	mg/l	0.05	0.1	0.5
9	Mercury	mg/l	0.005	0.01	0.5
10	Lead	mg/l	0.1	0.5	1.0
11	Cadmium	mg/l	0.005	0.01	0.5
12	Chromium (VI)	mg/l	0.05	0.1	0.5
13	Chromium (III)	mg/l	0.2	1	2
14	Copper	mg/l	2	2	5
15	Zinc	mg/l	3	3	5
16	Nickel	mg/l	0.2	0.5	2
17	Manganese	mg/l	0.5	1	5
18	Iron	mg/l	1	5	10
19	Tin	mg/l	0.2	1	5
20	Cyanide	mg/l	0.07	0.10	0.20
21	Phenol	mg/l	0.1	0.5	1
22	Mineral oil and grease	mg/l	5	5	10
23	Animal-vegetable fat and oil	mg/l	10	20	30
24	Residual chlorine	mg/l	1	2	-
25	PCBs	mg/l	0.003	0.01	-
26	Organic phosphorous	mg/l	0.3	1	-
27	Organic Chloride	mg/l	0.1	0.1	-
28	Sulfide	mg/l	0.2	0.5	1
29	Fluoride	mg/l	5	10	15
30	Chlorine	mg/l	500	600	1000
31	Ammonia (as N)	mg/l	5	10	15
32	Total nitrogen	mg/l	15	30	60
33	Total phosphorous	mg/l	4	6	8
34	Coliform	MPN/100m	3000	5000	-
35	Bioassay	-	90 % fish can stay alive in water for 96 hours		
36	Gross α activity	Bq/l	0.1	0.1	-
37	Gross β activity	Bq/l	1.0	1.0	-

Source: TCVN 5945-2005

(4) Quality of Water to Be Treated in the Sewage Treatment Plant

It is not economical for HHTP to provide high-grade treatment processes to remove specific substances that could be introduced into the sewage by each enterprise within the park. Therefore, if a tenant enterprise generates sewage that contains hazardous or toxic substances at higher concentrations than the regulated limitations as Class-A and

BOD_5 or SS (Suspended Solids) at higher than 300 mg/l respectively, they are to be obligated to construct their own pretreatment plant. Water quality examinations should be implemented at the discharge point of each enterprise in the High-Tech Industrial Zone and Research and Development Zone periodically.

6.3.3 Sector Development Plan

(1) Sewerage System and Collection Network

The plan of the sewerage system in HHTP is shown in Figure 6.3-1. Sewage treatment plant No. 1 (STP1) is under construction and sewage treatment plant No. 2 (STP2) is to be newly constructed.

STP1 treats the sewage from the area on the north side of the Lang – Hoa Lac Highway and STP2 is to treat that from the area on the south side of the Lang – Hoa Lac Highway, which is the Reserved Area. STP2 is planned so that the sewer pipe does not cross the 140m width of the Lang-Hoa Lac Highway in order to facilitate the construction and maintenance works.

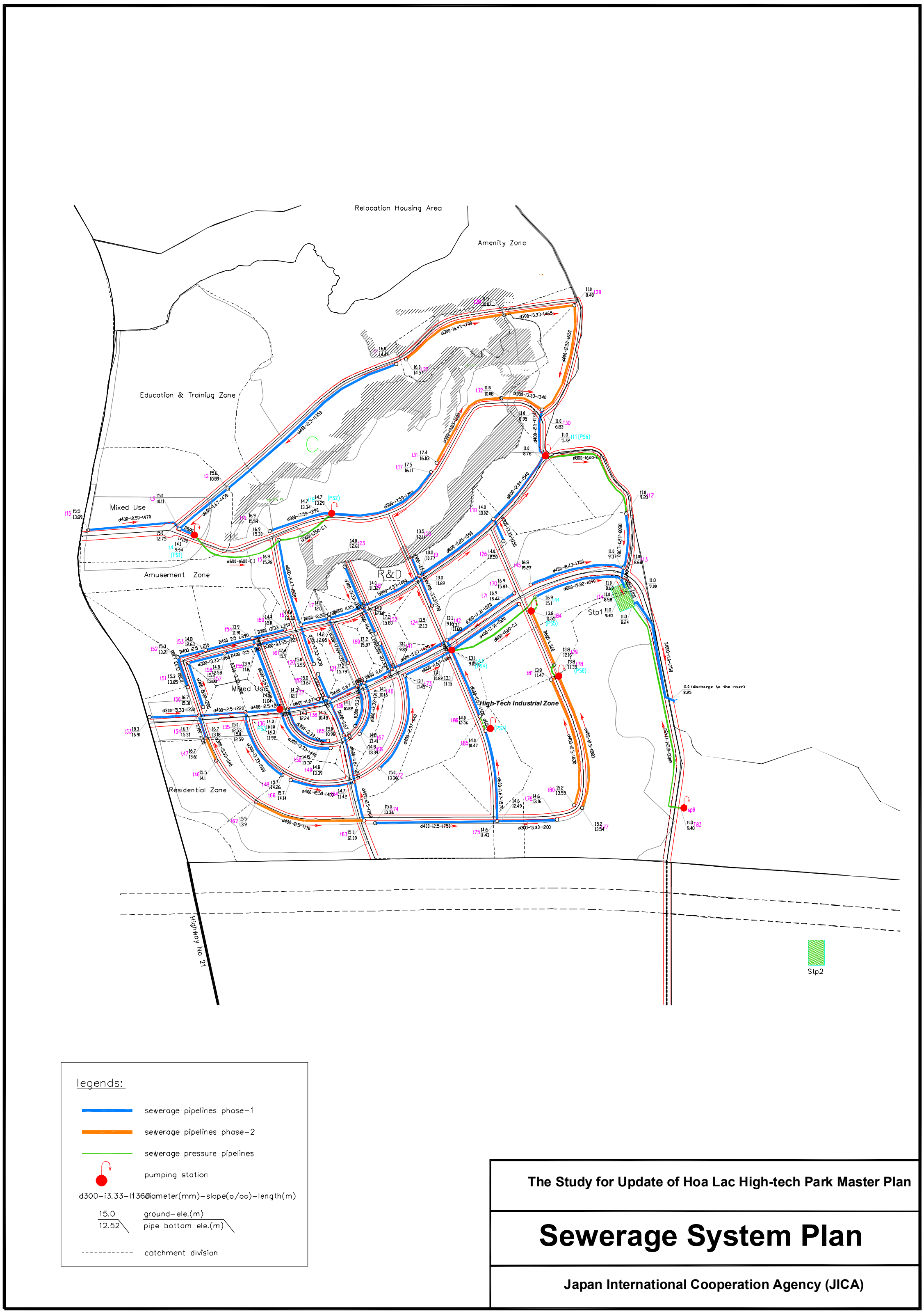
(2) Plan of Collection System

1) Outline of Collection System

The plan of the collection system is shown in Figure 6.3-2. A diagram of the collection system is shown in Figure 6.3-3.

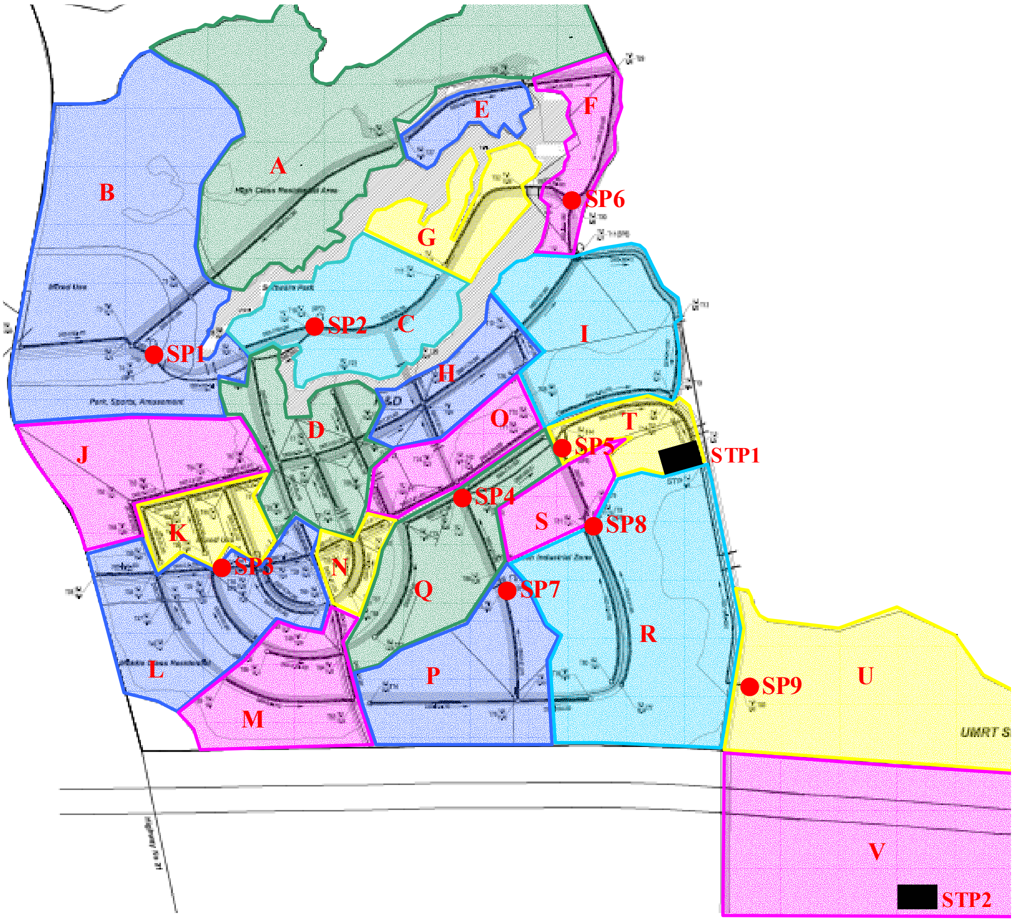
2) Pipeline at the river/lake-crossing point

The pipeline at the river/lake-crossing point will be put on bridges. However, at the point of the existing bridges, aqueduct bridges should be considered because the existing bridges may not be able to endure the load of the pipes and water.



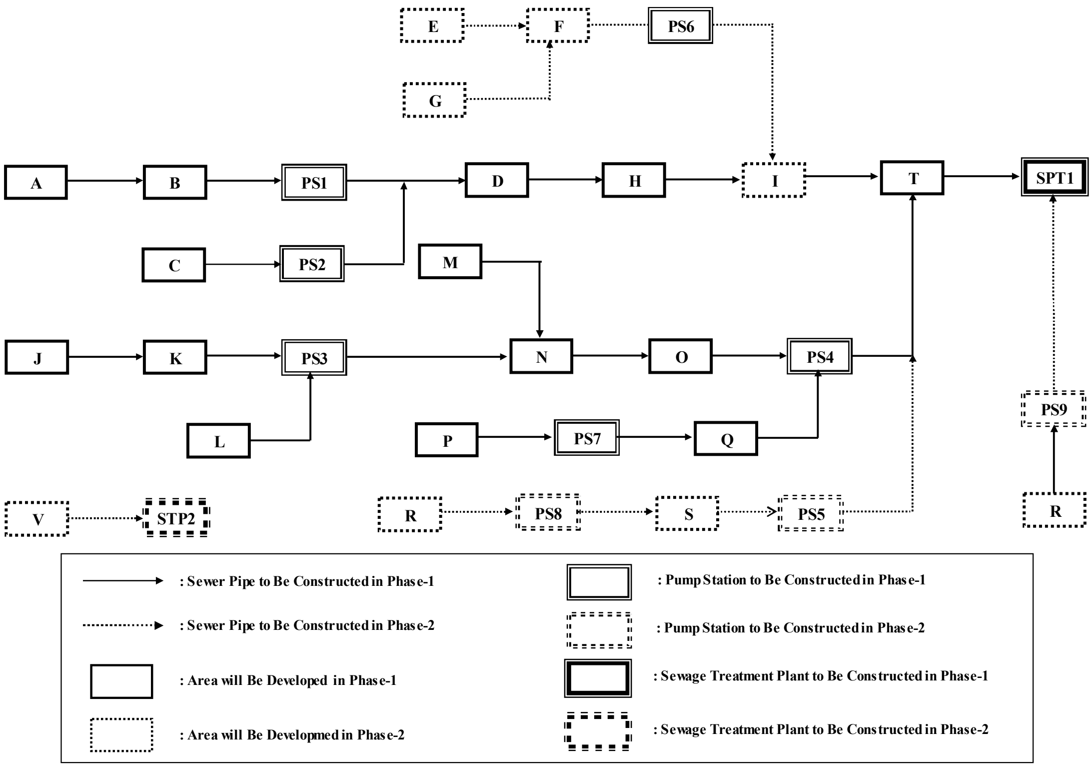
Source: JICA Study Team

Figure 6.3-1 Plan of Sewerage System



JICA Study Team

Figure 6.3-2 Plan of Catchments



Source: JICA Study Team

Figure 6.3-3 Diagram of Sewage Collection System

3) Capacity of Pump Stations

Capacities of pump stations are shown in Table 6.3-5. They are determined based on the hourly maximum sewage volume of their catchments. Capacity of each pump is planned in consideration of loads from phase-2.

Table 6.3-5 Capacities of Pump Stations

No.	Phase-1(2012)	Phase-2(2020)	Quantity in phase-2
PS1	80 l/s (80 l/s x 6.5 mH x 2 units)	240 l/s (80 l/s x 6.5 mH x 4 units)	202.01 l/s
PS2	20 l/s (20 l/s x 7.0 mH x 2units)	20 l/s (20 l/s x 7.0 mH x 2units)	15.93 l/s
PS3	80 l/s (80 l/s x 5.0 mH x 2units)	160 l/s (80 l/s x5.0 mH x 3 units)	150.00 l/s
PS4	160 l/s (80 l/s x 7.0 mH x 3 units)	320 l/s (80 l/s x 7.0 mH x 5 units)	300.28 l/s
PS5	-	130 l/s (65 l/s x 7.5 mH x 3 units)	125.23 l/s
PS6	160 l/s (80 l/s x 4.5 mH x 3 units)	320 l/s (80 l/s x 4.5 mH x 5 units)	294.82 l/s
PS7	65 l/s (65 l/s x 4.5 mH x 2units)	130 l/s (65 l/s x 4.5 mH x 3 units)	127.31 l/s
PS8	-	100 l/s (50 l/s x 5.5 mH x 3 units)	91.17 l/s
PS9	-	65 l/s (65 l/s x 7.0 mH x 2 units)	55.05 l/s

* All pump stations have 1 stand-by pump.
* Specification of pump stations for phase-2 is in total and includes that for phase-1.
Source: JICA Study Team

(3) Plan of Sewage Treatment Plants

1) Capacity of Sewage Treatment Plants

The required capacities of the sewage treatment plants are shown in Table 6.3-6.

Table 6.3-6 Capacities of Sewage Treatment Plants

(m^3/day)

No.	Items	Phase-1 (2012)	Phase-2 (2020)
STP1*[1]	Quantity	13,600	39,600
	Capacity	3,000 x 2 trains 8,500 x 1 trains Total: 14,500	3,000 x 2 trains 8,500 x 4 trains Total: 40,000
	Development Plan	8,500 x 1 train	8,500 x 3 trains
STP2*[2]	Quantity	0	8,800
	Capacity	-	4,500 x 2 trains Total: 9,000
	Development Plan	-	4,500 x 2 trains
Total	Quantity	13,600	48,400
	Capacity	14,000	49,000

*1: "3,000 x 2 trains" is under construction
*2: STP2 is to treat sewage from Reserved Area

Source: JICA Study Team

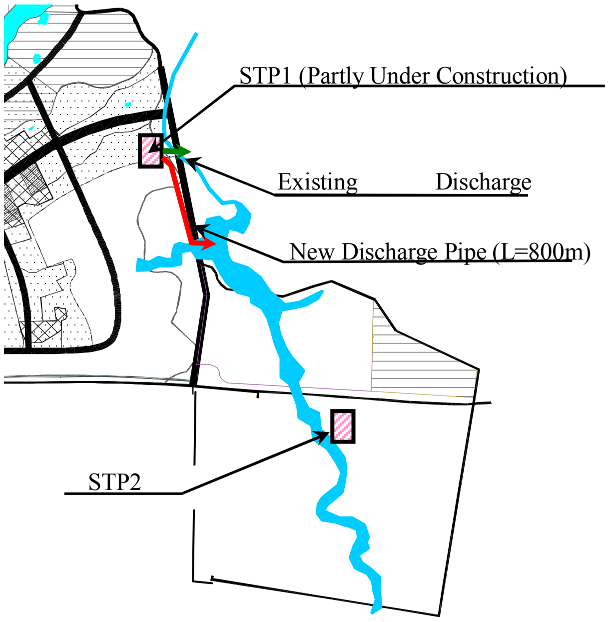
2) Location of Sewage Treatment Plants

From the viewpoints of economic advantage and hydraulic condition it is desirable that the sewage treatment plants be located along a river where treated water will be discharged. The location of STP1 is suitable and STP2 is proposed to be constructed near the river as shown in Figure 6.3-4.

However, there is concern that a large amount of discharge at one point may have some environmental impact on the Tich River because it is not very wide at the site of STP1. Therefore, a discharge pipe or culvert should be installed as indicated in Figure 6.3-4.

If the environmental impact is evaluated and it is proved that the total of discharge

(39,600 m^3/day) would not have an environmental impact, it is possible to integrate the discharge system to facilitate the operation and maintenance works.



Source: JICA Study Team

Figure 6.3-4 Location of Sewage Treatment Plants

3) Treatment Process

Conventional activated sludge process and oxidation ditch process are common treatment processes which are used for sewerage. Comparison of the processes is shown in Table 6.3-7. As shown in the table, the conventional activated sludge process is selected from the view point of land requirements and discharge water quality.

Table 6.3-7 Comparison of Treatment Processes

Items	Conventional Activated Sludge Process	Oxidation Ditch Process
Removal Ratio*	BOD: 90%	BOD: 80 %
	SS: 85 %	SS: 70 %
	☆	
Necessary Land* (Oxidation Ditch: 100)	55	100
	☆	
Cost	Same as Oxidation Ditch	Same as Conventional activated sludge process
	☆	☆
Maintenance	More complex to maintain than oxidation ditch process	Easy to operate and maintain
		☆
Evaluation	More complex to maintain. However, it enables more efficient utilization of land and quality of treated water is generally better.	It needs larger area to construct facilities.
	☆ (Selected)	-

* Ref: "Orientation for application of urban drainage and sewerage technology in Advancing Nations" (1993, International Development Institute)

Source: JICA Study Team

4) Area of Land for Sewage Treatment Plant

Area of land for sewage treatment plants are as follows.

Table 6.3-8 Area of Land for Sewage Treatment Plants

Plant No.	Capacity	Area
STP1*	40,000 m^3/day	6.0 ha
STP2	9,000 m^3/day	1.5 ha
Total	49,000 m^3/day	7.5 ha

*Land for Existing plant (6,000 m^3/day) is 0.9 ha.
Source: JICA Study Team

6.3.4 Development Issues

The existing collection system has been developed for only 200 ha of stage-1, which means that it does not have enough capacity for the whole area of HHTP. Even if some pipes have sufficient capacity, the depth will not meet the new plan in this MP and the position of the pipe is not consistent with the new road plan. Therefore, it will be unavoidable to remove the existing sewer pipe. And it is also necessary to study the method for switching the existing system to new system during the construction for phase-1.

6.4 Proposed Project List

Necessary projects in the sewerage sector for developing HHTP are shown in Table 6.4-1. The projects can be categorized into those to be implemented in phase-1, which are prioritized projects, and those to be implemented in phase-2.

Table 6.4-1 Project List for Sewerage

No.	Project	General description	Specification	Phase
1	Installation of Sewer Pipe for Phase-1	To install sewer pipes to collect wastewater and send it to water treatment plant for phase-1area	HCP 800mm x 3,300m HCP 600mm x 4,590m HCP 400mm x 6,590m HCP 300mm x 7,210m CIP 800mm x 1,260m CIP 600mm x 700m CIP 400mm x 1,300m CIP 300mm x 380m	1
2	Installation of Sewer Pipe for Phase-2	To install sewer pipes to collect wastewater and send it to water treatment plant for phase-2 area	HCP 600mm x 360m HCP 400mm x 3,120m HCP 300mm x 2,395m CIP 600mm x 200m	2
3	Construction of Pump Stations for Phase-1	To construct pump stations to pump up wastewater for phase-1	PS1: 80 l/s (80 l/s x 6.5 mH x 2 units, 1 stand-by) PS2: 20 l/s (20 l/s x 7.0 mH x 2 units, 1 stand-by) PS3: 80 l/s (80 l/s x 5.0 mH x 2 units, 1 stand-by) PS4: 160 l/s (80 l/s x 7.0 mH x 3 units, 1 stand-by) PS6: 160 l/s (80 l/s x 4.5 mH x 3 units, 1 stand-by) PS7: 65 l/s (65 l/s x 4.5 mH x 2 units, 1 stand-by)	1
4	Construction of Pump Stations for Phase-2	To construct or expand pump stations to pump up wastewater for phase-2	PS1: 240 l/s (80 l/s x 6.5 mH x 4 units in total, 1 stand-by) PS3: 160 l/s (80 l/s x 5.0 mH x 3 units in total, 1 stand-by) PS4: 320 l/s (80 l/s x 7.0 mH x 5 units in total, 1 stand-by) PS5: 130 l/s (65 l/s x 7.5 mH x 3 units, 1 stand-by) PS6: 320 l/s (80 l/s x 4.5 mH x 5 units in total, 1 stand-by) PS7: 130 l/s (65 l/s x 4.5 mH x 3 units in total, 1 stand-by) PS8: 100 l/s (50 l/s x 6.0 mH x 3 units, 1 stand-by) PS9: 65 l/s (65 l/s x 4.5 mH x 2 units, 1 stand-by)	2
5	Expansion of Water Sewage Plant for Phase-1 (STP1)	To expand the exsisting sewage treatment plant up to the capacity to meet the wastewater volume in phase-2	STP1: exp. 8,500m^3/day (8,500 x 1 trains)	1
6	Expansion of Sewage Treatment Plant for Phase-2 (STP1)	To expand the exsisting sewage treatment plant up to the capacity to meet the wastewater volume in phase-2	STP1: exp. 25,500m^3/day (8,500 x 3 trains)	2
7	Construction of Sewage Treatment for Phase-2 (STP2)	To construct a new sewage treatment plant for Reserved Area	STP2: 9,000m^3/day (4,500 x 2 trains)	2

Source: JICA Study Team

6.5 Technical Study for Phase-1 Development

6.5.1 Projects to Be Implemented in Phase-1

Projects to be implemented in phase-1 are shown in Table 6.5-1 and Figure 6.3-1. The projects are to construct a sewage treatment plant and sewage collection system including sewer pipes and pump stations for the phase-1 area.

Table 6.5-1 Projects to Be Implemented in Phase-1

Project	Specification	Remarks
Installation of Pipeline	HCP 800 mm x 3,300 m	
	HCP 600 mm x 4,590 m	
	HCP 400 mm x 6,590 m	
	HCP 300 mm x 7,210 m	
	CIP 800 mm x 1,260 m	
	CIP 600 mm x 700 m	
	CIP 400 mm x 1,300 m	
	CIP 300 mm x 380 m	
Construction of Sewage Treatment Plant	STP1: 8,500 m^3/day new construction (14,500 m^3/day including existing 6,000 m^3/day)	High-Tech Industrial Zone
Construction of Pump Stations	PS1: 80 l/s, 80 l/s x 6.5mH x 2 sets 1 stand-by	Software Park
	PS2: 20 l/s, 20 l/s x 7.0mH x 2 sets 1 stand-by	Software Park
	PS3: 80 l/s, 80 l/s x 5.0mH x 2 sets 1 stand-by	Mixed Use Zone
	PS4: 160 l/s, 80 l/s x 7.0mH x 3 sets 1 stand-by	High-Tech Industrial Zone
	PS6: 160 l/s, 80 l/s x 4.5mH x 3 sets 1 stand-by	Research and Development Zone
	PS7: 65 l/s, 65 l/s x 4.5mH x 2 sets 1 stand-by	High-Tech Industrial Zone

Source: JICA Study Team

6.5.2 Specifications for Sewage Treatment Plant

Specifications for Sewage Treatment plant for phase-1 are as follows.

Table 6.5-2 Outline of the Sewage Treatment Plant for Phase-1

Items	Outline
Cover Area	810 ha (Whole Area of HHTP phase-1)
Flow Quantity	13,600 m^3/day
Capacity	3,000 x 2 trains (Existing) 8,500 x 1 train (to be Expanded) Total: 14,500 m^3/day
Area	6.0 ha (Includes 0.9 ha of existing plant)
Treatment Process	Conventional Activated Sludge Process
Discharge Facility	□800 x 800, 1.0 ‰, L = 800m (Q=48,400m^3/day)

Source: JICA Study Team

6.5.3 Specifications for Pump Stations

Specifications for pump stations are shown in Table 6.5-1.

6.5.4 Study on Sewer Pipe

(1) Material of Sewer Pipes

Gravity flow sewer pipes (underground pipes and aerial pipes at bridges) and pressure flow sewer pipes will be installed in HHTP. Materials for these types of pipes should be selected in accordance with the use condition as described below.

1) Gravity Flow Pipe (Underground Pipe)

Hume pipe (HCP) and Polyvinyl chloride pipe (PVC) are commonly used for gravity flow pipes. In HHTP, HCP is recommended from the viewpoint of its durability.

2) Gravity Flow pipe (Aerial Pipe at the Bridges)

HCP is not suitable for the pipe on the bridge due to its heavy weight and PVC is not also applicable because it deteriorates if exposed to direct sunlight and also can be broken by accidental impact. Moreover, steel pipe (SP) tends to corrode if used for gravity flow sewage pipe. Therefore, Cast-iron pipe (CIP) is recommended for the gravity flow pipe at the bridges.

3) Pressure Flow Pipe

CIP and SP are commonly used for pressure flow pipes. In HHTP, CIP is recommended from the viewpoint of cost and dependability because there is no need for welding work.

Table 6.5-3 Materials of Sewer Pipes in HHTP

Type of Pipe		Material
Gravity Flow	Underground Pipe	Hume Pipe (HCP)
	Aerial Pipe (on Bridge)	Cast-Iron Pipe (CIP)
Pressure Flow	Underground and aerial pipe	Cast-Iron Pipe (CIP)

Source: JICA Study Team

(2) Method to Cross the Rivers/Lakes

There are some places that the sewer pipes cross a river or lake. The collection system was considered so that the depth of the pipes may be less than or equal to 1.5 m in order to make it possible to put the pipes on the bridge. The method to cross the rivers/lakes is described and shown below.

1) Case-1 (Depth of the sewer pipe is less than or equal to 1.5 m)

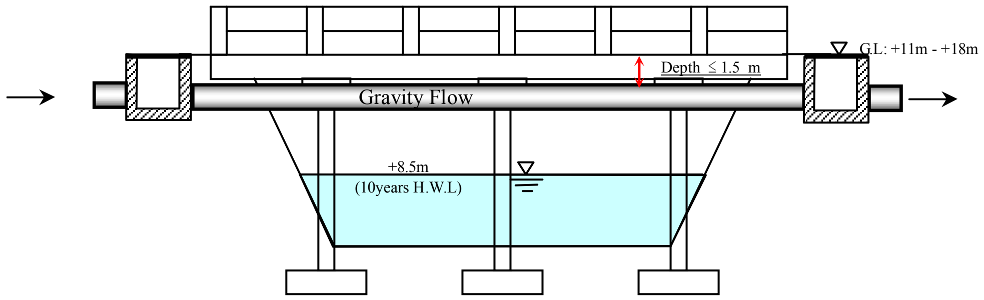
If the depth of the sewer pipe is less than or equal to 1.5 m, the pipes can be installed as gravity flow pipe as shown in Figure 6.5-1.

2) Case-2 (Depth of the sewer pipe is over 1.5 m)

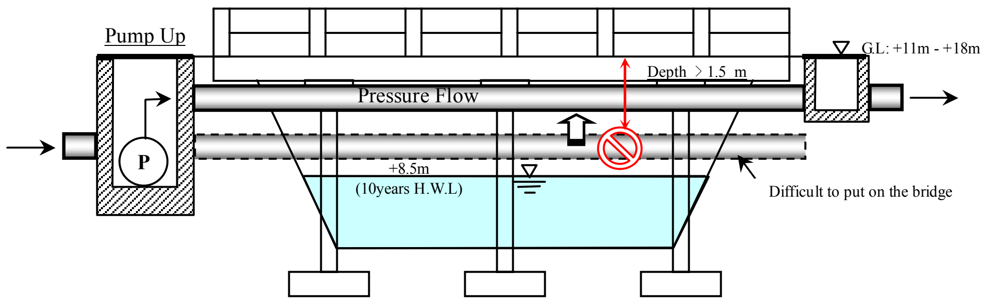
If the depth of the sewer pipe is greater than 1.5 m, the sewage should pumped up in a lift station and the pipes installed as pressure flow pipe as shown in Figure 6.5-

1.

[Case-1] Depth of the sewer pipe ≦ 1.5 m



[Case-2] Depth of the sewer pipe > 1.5 m



Source: JICA Study Team

Figure 6.5-1 Methods to Cross the Rivers and Lakes

6.5.5 Hydraulic Analysis of the Sewerage Collection System

(1) Target Area for Calculation

Hydraulic analysis has been conducted to determine the diameter, gradient and depth of the sewer pipes. Sewer pipes to be installed in phase-1 are to be designed so that they will also be utilized in phase-2, because it is not realistic to install new pipeline for the phase-2 area beside the phase-1 sewer pipes or to demolish the phase-1 sewer pipes and replace them with a new sewage collection system.

Therefore, in this study, the target area for calculation is the whole HHTP area except for the East part of the High-Tech Industrial Zone and the Housing Complex, and Reserved Area, for which sewage treatment plants will be constructed in each area to serve those areas exclusively.

(2) Analysis Condition

1) Basic Formula for Analysis

Basic formula for analysis of water supply network is Manning's Formula as shown follows.

$$Q = A \times V$$

$$V = (1/n) \times R^{2/3} \times I^{1/2}$$

Where, Q : Sewage flow rate (m^3/sec)
A : Cross sectional area of pipe (m^2)
V : Velocity (m/sec)
n : Roughness coefficient of pipe, 0.013, (-)
I : Hydraulic gradient (-)
R : Hydraulic radius, (m)

2) Design Criteria (TVCN51-1984)

a) Velocity of flow

Velocity flow should follow the values below in principle.

Minimum : 0.7 m/s

Maximum : 4.0 m/s

b) Minimum Slope

Minimum slope of the sewer pipe is defined as 1/D (D: diameter) as summarized below;

Table 6.5-4 Minimum Slope of Sewer Pipe

Diameter (mm)	Minimum Slope (‰)
300	3.33
400	2.50
500	2.00
600	1.67
700	1.43
800	1.25

Minimum Slope = 1/D (D: Diameter of sewer pipe) (TVCN51-1984)
Source: JICA Study Team

c) Safety Ratio (Water Depth in Sewer Pipe)

Water depth in the sewer pipes should follow the table below as a safety margin.

Table 6.5-5 Maximum Water Depth

Diameter (mm)	Fullness (h/H)
200 – 300	0.60
350 – 450	0.70
500 – 900	0.75
> 900	0.80

h: Water Depth, H: Inside dimension of pipe
Source: JICA Study Team

(3) Result of the Hydraulic Analysis

Result of the hydraulic analysis is as follows.

Calculation Sheet for Sewerage (1/4)

ELEVATION AND CUT/FILL VOLUME OF LINKS AND NODES

Version: E

Project: Hoa Lac HP
Items: Sewerage network — Hu_min: 0.3 — Hmax: 6.00 — Engineer: 0
No of pipe 84 — Ho_min: 1.0 — Macro: Ctr+E

Index	In	Out	Length	Level	Cultvert/ Pipe	Dia	i_cal'	Fullness	Head end elevation (m)			Tail end elevation (m)			i_true	Depth (m)			C.Vol	Fill back	H_pump		Q_pump	
	node	node	(m)	14	(U/O)	(mm)	(o/oo)	(mm)	Ground	Invert	W level	Ground	Invert	W level	(o/oo)	First	End	Aver.	m3	(m3)	Head (m)	Tail (m)	(l/s)	
1	T1	T2	1350	1	O	400	2.50	162	16.00	14.44	14.60	15.60	11.06	11.23	2.50	1.56	4.54	3.05	3641.85	3641.73				
2	T2	T3	430	2	O	600	1.67	340	15.60	10.89	11.23	15.00	10.17	10.51	1.67	4.71	4.83	4.77	2313.32	2313.04				
3	T3	T4	100	3	O	600	1.67	400	15.00	10.11	10.51	14.10	9.94	10.34	1.67	4.89	4.16	4.53	509.89	509.61				
4	T4	T5	600	4	O	600	1.08	400	14.10	9.94	10.34	16.90	15.30	15.70	-8.93	4.16	1.60	2.88	1942.32	1942.04		6.36	202.01	PS1
5	T5	T6	530	5	O	600	1.67	421	16.90	15.28	15.70	14.40	12.38	12.80	5.47	1.62	2.02	1.82	1083.63	1083.35				
6	T6	T7	180	6	O	800	1.25	394	14.40	12.41	12.80	14.20	12.01	12.40	2.22	1.99	2.19	2.09	513.69	513.18				
7	T7	T8	200	7	O	800	1.25	402	14.20	12.00	12.40	14.00	11.75	12.15	1.25	2.20	2.25	2.23	607.33	606.83				
8	T8	T9	400	8	O	800	1.25	415	14.00	11.32	11.73	13.00	10.79	11.20	1.33	2.68	2.21	2.45	1335.36	1334.86				
9	T9	T10	590	9	O	800	1.25	426	13.00	10.77	11.20	14.00	10.04	10.46	1.25	2.23	3.96	3.10	2491.99	2491.49				
10	T10	T11	540	10	O	800	1.25	438	14.00	10.02	10.46	11.00	8.76	9.20	2.34	3.98	2.24	3.11	2289.68	2289.18				
11	T11	T12	660	11	O	800	0.81	454	11.00	5.72	6.18	11.00	9.20	9.65	-5.27	5.28	1.80	3.54	3189.26	3188.76		4.30	294.82	PS6
12	T12	T13	380	12	O	800	1.25	454	11.00	9.20	9.65	11.00	8.73	9.18	1.25	1.80	2.28	2.04	1055.35	1054.84				
13	T13	T14	50	13	O	800	1.25	496	11.00	8.68	9.18	11.00	8.62	9.12	1.25	2.32	2.38	2.35	160.15	159.65				
14	T14	STP	100	14	O	800	1.25	539	11.00	8.58	9.12	11.00	8.24	8.78	3.38	2.42	2.76	2.59	353.44	352.94				
15	T15	T3	470	1	O	400	2.50	207	15.50	13.89	14.10	15.00	12.72	12.93	2.50	1.61	2.28	1.94	806.82	806.69				
16	T17	T18	780	1	O	300	3.33	85	17.50	16.11	16.20	14.70	13.31	13.40	3.59	1.39	1.39	1.39	823.56	823.49				
17	T18	T5	350	2	O	300	2.17	107	14.70	13.29	13.40	16.90	15.60	15.71	-6.59	1.41	1.30	1.35	361.04	360.97		6.81	15.93	PS2
18	T19	T18	290	1	O	300	3.33	64	16.90	15.54	15.60	14.70	13.34	13.40	7.59	1.36	1.36	1.36	301.34	301.27				
19	T20	T6	230	1	O	300	3.33	146	15.00	13.55	13.70	14.40	12.79	12.93	3.33	1.45	1.61	1.53	268.10	268.03				
20	T21	T7	390	1	O	300	3.33	106	17.20	15.79	15.90	14.20	12.79	12.90	7.69	1.41	1.41	1.41	417.86	417.79				
21	T22	T8	190	1	O	300	3.33	70	17.20	15.83	15.90	14.00	12.63	12.70	16.84	1.37	1.37	1.37	198.41	198.34				
22	T23	T8	290	1	O	300	3.33	91	14.00	12.61	12.70	14.00	11.64	11.73	3.33	1.39	2.36	1.87	414.61	414.54				
23	T24	T9	190	1	O	300	3.33	70	13.50	12.13	12.20	13.00	11.50	11.57	3.33	1.37	1.50	1.44	208.09	208.02				
24	T25	T9	120	1	O	300	3.33	56	13.50	12.14	12.20	13.00	11.64	11.70	4.17	1.36	1.36	1.36	123.99	123.92				
25	T26	T10	150	1	O	300	3.33	108	14.00	12.59	12.70	14.00	12.09	12.20	3.33	1.41	1.91	1.66	189.66	189.59				
26	T27	T28	700	1	O	300	3.33	126	16.00	14.57	14.70	11.50	10.07	10.20	6.43	1.43	1.43	1.43	760.84	760.77				
27	T28	T29	465	2	O	300	3.33	129	11.50	10.07	10.20	11.00	8.52	8.65	3.33	1.43	2.48	1.95	693.09	693.02				
28	T29	T30	650	3	O	400	2.50	166	11.00	8.48	8.65	11.00	6.86	7.03	2.50	2.52	4.14	3.33	1914.92	1914.80				
29	T30	T11	340	4	O	400	2.50	198	11.00	6.83	7.03	11.00	5.98	6.18	2.50	4.17	5.02	4.60	1386.56	1386.43				
30	T31	T32	600	1	O	300	3.33	75	17.40	16.03	16.10	11.50	10.13	10.20	9.83	1.37	1.37	1.37	628.56	628.49				
31	T32	T30	340	2	O	300	3.33	121	11.50	10.08	10.20	11.00	8.95	9.07	3.33	1.42	2.05	1.74	450.56	450.49				
32	T33	T34	300	1	O	300	3.33	92	18.30	16.91	17.00	16.70	15.31	15.40	5.33	1.39	1.39	1.39	318.34	318.27				
33	T34	T35	220	2	O	400	2.50	160	16.70	13.14	13.30	15.00	12.59	12.75	2.50	3.56	2.41	2.98	580.75	580.63				
34	T35	T36	260	3	O	400	2.50	206	15.00	12.53	12.73	14.30	11.88	12.08	2.50	2.47	2.42	2.45	562.31	562.19				
35	T51	T52	180	1	O	300	3.33	147	15.30	13.85	14.00	15.30	13.25	13.40	3.33	1.45	2.05	1.75	239.75	239.68				
36	T52	T53	210	2	O	400	2.50	191	15.30	13.21	13.40	14.80	12.68	12.88	2.50	2.09	2.12	2.10	390.15	390.03				
37	T53	T54	290	3	O	400	2.50	243	14.80	12.63	12.88	13.90	11.91	12.15	2.50	2.17	1.99	2.08	532.77	532.64				
38	T54	T55	50	4	O	600	1.67	236	13.90	11.91	12.15	13.90	11.83	12.07	1.67	1.99	2.07	2.03	113.84	113.56				
39	T55	T36	420	5	O	600	1.67	264	13.90	11.80	12.07	14.30	11.10	11.37	1.67	2.10	3.20	2.65	1249.71	1249.42				
40	T36	T37	30	6	O	600	1.08	328	14.30	11.04	11.37	14.30	12.70	13.03	-55.39	3.26	1.60	2.43	81.94	81.66		3.00	150.00	PS3
41	T37	T38	310	7	O	600	1.67	353	14.30	12.01	12.37	14.50	11.50	11.85	1.67	2.29	3.00	2.65	921.61	921.33				
42	T38	T39	150	8	O	600	1.67	375	14.50	10.48	10.86	14.10	10.23	10.61	1.67	4.02	3.87	3.94	665.74	665.46				
43	T39	T40	30	9	O	600	1.67	385	14.10	10.22	10.61	14.10	10.17	10.56	1.67	3.88	3.93	3.90	131.78	131.49				
44	T40	T41	160	10	O	600	1.67	396	14.10	10.16	10.56	13.10	9.90	10.29	1.67	3.94	3.20	3.57	643.03	642.75				
45	T41	T42	420	11	O	600	1.67	405	13.10	9.89	10.29	13.10	9.19	9.59	1.67	3.21	3.91	3.56	1684.03	1683.75				
46	T42	T43	50	12	O	600	1.67	428	13.10	9.16	9.59	13.10	9.08	9.51	1.67	3.94	4.02	3.98	223.96	223.68				
47	T43	T44	600	13	O	800	0.81	459	13.10	9.05	9.51	16.90	15.10	15.56	-10.08	4.05	1.80	2.93	2394.84	2394.34		5.80	300.28	PS4

Calculation Sheet for Sewerage (2/4)

Index	In	Out	Length	Level	Cultvert/ Pipe	Dia	i_cal'	Fullness	Head end elevation (m)			Tail end elevation (m)			i_true	Depth (m)			C.Vol	Fill	H_pump		Q_pump	
	node	node	(m)	14	(U/O)	(mm)	(o/oo)	(mm)	Ground	Invert	W level	Ground	Invert	W level	(o/oo)	First	End	Aver.	m3	back (m3)	Head (m)	Tail (m)	(l/s)	
48	T44	T14	690	14	O	800	1.25	507	16.90	15.05	15.56	11.00	8.69	9.20	9.22	1.85	2.31	2.08	1954.07	1953.57				
49	T45	T13	700	1	O	400	2.50	229	16.90	15.27	15.50	11.00	9.37	9.60	8.43	1.63	1.63	1.63	1006.49	1006.36				
50	T46	T47	140	1	O	300	3.33	105	15.50	14.10	14.20	16.70	13.63	13.73	3.33	1.40	3.07	2.24	239.21	239.14				
51	T47	T34	130	2	O	300	3.33	121	16.70	13.61	13.73	16.70	13.18	13.30	3.33	3.09	3.52	3.30	328.60	328.53				
52	T48	T35	500	1	O	300	3.33	139	15.70	14.26	14.40	15.00	12.59	12.73	3.33	1.44	2.41	1.92	733.27	733.20				
53	T49	T36	440	1	O	300	3.33	112	14.80	13.39	13.50	14.30	11.92	12.03	3.33	1.41	2.38	1.90	636.28	636.21				
54	T50	T37	340	1	O	300	3.33	126	14.80	13.37	13.50	14.30	12.24	12.37	3.33	1.43	2.06	1.74	451.85	451.78				
55	T56	T57	280	1	O	300	3.33	89	16.70	15.31	15.40	15.30	13.91	14.00	5.00	1.39	1.39	1.39	296.44	296.37				
56	T57	T58	260	2	O	300	3.33	124	15.30	13.88	14.00	14.80	13.01	13.13	3.33	1.42	1.79	1.61	318.65	318.58				
57	T58	T55	180	3	O	400	2.50	156	14.80	12.58	12.73	13.90	12.13	12.28	2.50	2.22	1.77	2.00	317.50	317.38				
58	T59	T58	290	1	O	300	3.33	91	15.00	13.61	13.70	14.80	12.64	12.73	3.33	1.39	2.16	1.77	392.41	392.34				
59	T60	T54	210	1	O	300	3.33	99	14.40	13.00	13.10	13.90	12.30	12.40	3.33	1.40	1.60	1.50	239.99	239.92				
60	T61	T55	220	1	O	300	3.33	102	17.10	15.70	15.80	13.90	12.50	12.60	14.55	1.40	1.40	1.40	235.04	234.96				
61	T62	T63	710	1	O	400	2.50	203	15.50	13.90	14.10	15.00	12.12	12.33	2.50	1.60	2.88	2.24	1405.32	1405.20				
62	T63	T64	260	2	O	400	2.50	232	15.00	12.09	12.33	14.70	11.44	11.68	2.50	2.91	3.26	3.08	708.95	708.83				
63	T64	T65	260	3	O	600	1.67	252	14.70	11.42	11.68	15.00	10.99	11.24	1.67	3.28	4.01	3.64	1066.29	1066.01				
64	T65	T38	230	4	O	600	1.67	264	15.00	10.98	11.24	14.50	10.59	10.86	1.67	4.02	3.91	3.96	1026.46	1026.18				
65	T66	T64	400	1	O	400	2.50	161	15.70	14.14	14.30	14.70	13.14	13.30	2.50	1.56	1.56	1.56	550.93	550.80				
66	T67	T39	240	1	O	300	3.33	106	14.80	13.39	13.50	14.10	12.59	12.70	3.33	1.41	1.51	1.46	266.40	266.33				
67	T68	T40	310	1	O	300	3.33	94	14.80	13.41	13.50	14.10	12.37	12.47	3.33	1.39	1.73	1.56	368.83	368.76				
68	T69	T41	150	1	O	300	3.33	65	17.20	15.84	15.90	13.10	11.74	11.80	27.33	1.36	1.36	1.36	156.02	155.95				
69	T70	T42	520	1	O	300	3.33	163	16.90	15.44	15.60	13.10	11.64	11.80	7.31	1.46	1.46	1.46	580.04	579.97				
70	T71	T43	520	1	O	400	2.50	202	16.90	15.30	15.50	13.10	11.50	11.70	7.31	1.60	1.60	1.60	735.25	735.13				
71	T72	T73	640	1	O	400	2.50	219	15.00	13.38	13.60	13.10	11.48	11.70	2.97	1.62	1.62	1.62	914.33	914.20				
72	T73	T43	380	2	O	600	1.67	245	13.10	11.45	11.70	13.10	10.82	11.07	1.67	1.65	2.28	1.96	837.11	836.83				
73	T74	T75	750	1	O	400	2.50	238	15.00	13.36	13.60	14.60	11.49	11.73	2.50	1.64	3.11	2.38	1574.17	1574.04				
74	T75	T85	570	2	O	600	1.67	298	14.60	11.43	11.73	13.80	10.48	10.78	1.67	3.17	3.32	3.25	2082.27	2081.98				
75	T85	T86	100	3	O	600	1.08	307	13.80	10.47	10.78	14.00	12.40	12.71	-19.32	3.33	1.60	2.47	277.10	276.81		4.43	127.31	PS7
76	T86	T43	500	4	O	600	1.67	350	14.00	12.36	12.71	13.10	11.15	11.50	2.41	1.64	1.95	1.80	1008.71	1008.42				
77	T76	T75	200	1	O	300	3.33	144	14.60	13.16	13.30	14.60	12.49	12.63	3.33	1.44	2.11	1.78	271.17	271.10				
78	T77	T78	880	1	O	400	2.50	259	15.20	13.54	13.80	13.80	11.34	11.60	2.50	1.66	2.46	2.06	1600.07	1599.94				
79	T78	T79	100	2	O	600	1.08	246	13.80	11.35	11.60	13.80	12.20	12.45	-8.46	2.45	1.60	2.02	227.19	226.91		5.01	91.17	PS8
80	T79	T84	360	3	O	600	1.67	285	13.80	12.16	12.45	14.00	11.56	11.85	1.67	1.64	2.44	2.04	824.37	824.09				
81	T84	T44	100	4	O	600	1.08	295	14.00	11.55	11.85	16.90	15.30	15.59	-37.49	2.45	1.60	2.02	227.35	227.07		7.08	125.23	PS5
82	T80	T81	830	1	O	400	2.50	251	15.20	13.55	13.80	13.80	11.47	11.73	2.50	1.65	2.33	1.99	1457.31	1457.18				
83	T81	T78	50	2	O	400	2.50	259	13.80	11.47	11.73	13.80	11.34	11.60	2.50	2.33	2.46	2.40	105.88	105.75				
84	T82	T38	160	1	O	300	3.33	86	15.00	13.61	13.70	14.50	13.08	13.17	3.33	1.39	1.42	1.40	171.07	170.99				
85	T83	STP	1450	1	O	400	1.63	203	11.00	9.40	9.60	11.00	6.15	6.35	2.24	1.60	4.85	3.23	4141.05	4140.92		7.00	53.05	PS9

Calculation Sheet for Sewerage (3/4)

HYDRAULIC CALCULATION FOR CIRCULAR SEWER PIPES

Project: Hoa Lac HP
Item: Sewerage network
No of pip 84

Version:	E	4-Aug-07
Macro:	Ctr+T	
Engineer:		

Index	In node	Out node	Length (m)	Q (l/s)	Material (C/P/S)	Slope (o/oo)	Dia (mm)	V (m/s)	h/D	Fullness (mm)	HL (m)
1	T1	T2	1350	37.278	C	2.50	400	0.78	0.41	162	3.375
2	T2	T3	430	158.062	C	1.67	600	0.96	0.57	340	0.717
3	T3	T4	100	202.005	C	1.67	600	1.01	0.67	400	0.167
4	T4	T5	600	202.005	C.I	1.08	600	1.01	0.67	400	1.000
5	T5	T6	530	216.474	C	1.67	600	1.02	0.70	421	0.883
6	T6	T7	180	233.234	C	1.25	800	0.95	0.49	394	0.225
7	T7	T8	200	242.319	C	1.25	800	0.96	0.50	402	0.250
8	T8	T9	400	254.777	C	1.25	800	0.97	0.52	415	0.500
9	T9	T10	590	266.698	C	1.25	800	0.98	0.53	426	0.738
10	T10	T11	540	279.119	C	1.25	800	0.99	0.55	438	0.675
11	T11	T12	660	294.823	C.I	0.81	800	1.00	0.57	454	0.825
12	T12	T13	380	294.823	C	1.25	800	1.00	0.57	454	0.475
13	T13	T14	50	338.655	C	1.25	800	1.03	0.62	496	0.063
14	T14	STP	270	380.698	C	1.25	800	1.06	0.67	539	0.338
15	T15	T3	470	56.971	C	2.50	400	0.87	0.52	207	1.175
16	T17	T18	780	10.288	C	3.33	300	0.62	0.28	85	2.600
17	T18	T5	350	15.935	C.I	2.17	300	0.70	0.36	107	4.500
18	T19	T18	290	5.738	C	3.33	300	0.53	0.21	64	0.967
19	T20	T6	230	27.583	C	3.33	300	0.81	0.49	146	0.767
20	T21	T7	390	15.528	C	3.33	300	0.70	0.35	106	1.300
21	T22	T8	190	7.030	C	3.33	300	0.56	0.23	70	0.633
22	T23	T8	290	11.584	C	3.33	300	0.64	0.30	91	0.967
23	T24	T9	190	7.030	C	3.33	300	0.56	0.23	70	0.633
24	T25	T9	120	4.440	C	3.33	300	0.49	0.19	56	0.400
25	T26	T10	150	16.163	C	3.33	300	0.70	0.36	108	0.500
26	T27	T28	700	21.404	C	3.33	300	0.76	0.42	126	2.333
27	T28	T29	465	22.176	C	3.33	300	0.77	0.43	129	1.550
28	T29	T30	650	39.006	C	2.50	400	0.79	0.42	166	1.625
29	T30	T11	340	53.008	C	2.50	400	0.85	0.50	198	0.850
30	T31	T32	600	7.914	C	3.33	300	0.58	0.25	75	2.000
31	T32	T30	340	19.868	C	3.33	300	0.74	0.40	121	1.133
32	T33	T34	300	11.983	C	3.33	300	0.65	0.31	92	1.000
33	T34	T35	220	36.153	C	2.50	400	0.77	0.40	160	0.550
34	T35	T36	260	56.472	C	2.50	400	0.87	0.51	206	0.650
35	T51	T52	180	27.851	C	3.33	300	0.81	0.49	147	0.600
36	T52	T53	210	49.875	C	2.50	400	0.84	0.48	191	0.525
37	T53	T54	290	73.527	C	2.50	400	0.92	0.61	243	0.725
38	T54	T55	50	84.325	C	1.67	600	0.82	0.39	236	0.083
39	T55	T36	420	103.404	C	1.67	600	0.86	0.44	264	0.700
40	T36	T37	30	149.998	C.I	1.08	600	0.95	0.55	328	2.667
41	T37	T38	310	168.421	C	1.67	600	0.97	0.59	353	0.517

Calculation Sheet for Sewerage (4/4)

Index	In node	Out node	Length (m)	Q (l/s)	Material (C/P/S)	Slope (o/oo)	Dia (mm)	V (m/s)	h/D	Fullness (mm)	HL (m)
42	T38	T39	150	184.352	C	1.67	600	0.99	0.63	375	0.250
43	T39	T40	30	191.255	C	1.67	600	1.00	0.64	385	0.050
44	T40	T41	160	199.360	C	1.67	600	1.01	0.66	396	0.267
45	T41	T42	420	205.201	C	1.67	600	1.01	0.67	405	0.700
46	T42	T43	50	221.064	C	1.67	600	1.02	0.71	428	0.083
47	T43	T44	600	300.278	CI	0.81	800	1.01	0.57	459	0.750
48	T44	T14	690	349.495	C	1.25	800	1.04	0.63	507	0.863
49	T45	T13	700	67.412	C	2.50	400	0.90	0.57	229	1.750
50	T46	T47	140	15.268	C	3.33	300	0.69	0.35	105	0.467
51	T47	T34	130	19.861	C	3.33	300	0.74	0.40	121	0.433
52	T48	T35	500	25.441	C	3.33	300	0.79	0.46	139	1.667
53	T49	T36	440	17.324	C	3.33	300	0.72	0.37	112	1.467
54	T50	T37	340	21.359	C	3.33	300	0.76	0.42	126	1.133
55	T56	T57	280	11.184	C	3.33	300	0.64	0.30	89	0.933
56	T57	T58	260	20.782	C	3.33	300	0.75	0.41	124	0.867
57	T58	T55	180	34.663	C	2.50	400	0.77	0.39	156	0.450
58	T59	T58	290	11.584	C	3.33	300	0.64	0.30	91	0.967
59	T60	T54	210	13.746	C	3.33	300	0.67	0.33	99	0.700
60	T61	T55	220	14.401	C	3.33	300	0.68	0.34	102	0.733
61	T62	T63	710	55.278	C	2.50	400	0.86	0.51	203	1.775
62	T63	T64	260	68.758	C	2.50	400	0.91	0.58	232	0.650
63	T64	T65	260	95.306	C	1.67	600	0.84	0.42	252	0.433
64	T65	T38	230	103.101	C	1.67	600	0.86	0.44	264	0.383
65	T66	T64	400	36.728	C	2.50	400	0.78	0.40	161	1.000
66	T67	T39	240	15.648	C	3.33	300	0.70	0.35	106	0.800
67	T68	T40	310	12.383	C	3.33	300	0.65	0.31	94	1.033
68	T69	T41	150	5.992	C	3.33	300	0.53	0.22	65	0.500
69	T70	T42	520	33.420	C	3.33	300	0.85	0.54	163	1.733
70	T71	T43	520	54.970	C	2.50	400	0.86	0.51	202	1.300
71	T72	T73	640	62.565	C	2.50	400	0.89	0.55	219	1.600
72	T73	T43	380	90.383	C	1.67	600	0.83	0.41	245	0.633
73	T74	T75	750	71.317	C	2.50	400	0.92	0.59	238	1.875
74	T75	T85	570	127.313	C	1.67	600	0.91	0.50	298	0.950
75	T85	T86	100	134.117	CI	1.08	600	0.92	0.51	307	0.167
76	T86	T43	500	166.148	C	1.67	600	0.97	0.58	350	0.833
77	T76	T75	200	27.163	C	3.33	300	0.81	0.48	144	0.667
78	T77	T78	880	80.904	C	2.50	400	0.94	0.65	259	2.200
79	T78	T79	100	91.169	CI	1.08	600	0.83	0.41	246	2.500
80	T79	T84	360	118.178	C	1.67	600	0.89	0.47	285	0.600
81	T84	T44	100	125.234	CI	1.08	600	0.91	0.49	295	2.500
82	T80	T81	830	77.314	C	2.50	400	0.93	0.63	251	2.075
83	T81	T78	50	80.904	C	2.50	400	0.94	0.65	259	0.125
84	T82	T38	160	10.473	C	3.33	300	0.62	0.29	86	0.533
83	T83	STP	1300	55.045	CI	1.63	400	0.86	0.51	203	3.250

6.5.6 Project Cost

The direct project construction cost is estimated based on the following conditions and assumptions; however, these are subject to change in a later stage based on the further study/design result and market price.

The construction cost of the works is estimated based on the following conditions.

(1) The quantities of the works are roughly estimated based on the preliminary design.

(2) The unit prices of the work are estimated based on the prices in the similar project and converted into 2007 current price.

(3) Exchange rate: 1 USD = 120 JPY = 16,000 VND.

(4) Value Added Tax (VAT) and Import Tax are excluded.

Table 6.5-6 Project Cost for Sewerage

No.	Project	Specification	unit	Unit Cost (USD)	Phase-1		Phase-2		TOTAL		Remarks
					Quantity	Cost (USD)	Quantity	Cost (USD)	Quantity	Cost (USD)	
1	Installation of Sewer Pipes	HCP 800mm	m	145	3,300	478,500		0	3,300	478,500	Includes Maintenace Hall
		HCP 500mm - 600mm	m	85	4,590	390,150	360	30,600	4,950	420,750	Includes Maintenace Hall
		HCP 300mm - 400mm	m	50	13,800	690,000	5,515	275,750	19,315	965,750	Includes Maintenace Hall
		CIP 800mm	m	1,210	1,260	1,524,600		0	1,260	1,524,600	
		CIP 600mm	m	610	700	427,000	200	122,000	900	549,000	Pressure Flow Pipe
		CIP 300mm - 400mm	m	310	1,680	520,800		0	1,680	520,800	Pressure Flow Pipe
		Accessorie(valve, meter, etc)	lot	121,000	1	121,000		0	1	121,000	
		Total				**4,152,050**		**428,350**		**4,580,400**	
2	Construction of Pump Stations	PS01: 240 l/s (P=80 l/s x2)	set	290,000	1	290,000		0	1	290,000	
		pump for SP01 (P=80 ls x2)		194,000		0	1	194,000	1	194,000	
		PS02: 20 l/s (P=20 ls x2)	set	60,500	1	60,500		0	1	60,500	
		PS03: 160 l/s (P=80 l/s x2)	set	225,000	1	225,000		0	1	225,000	
		pump for SP01 (P=80 ls x1)		97,000		0	1	97,000	1	97,000	
		PS04: 320 l/s (P=80 l/s x3)	set	451,000	1	451,000		0	1	451,000	
		pump for SP01 (P=80 ls x2)		194,000		0	1	194,000	1	194,000	
		PS05: 130 l/s (P=65 l/s x3)	set	242,000		0	1	242,000	1	242,000	
		PS06: 320 l/s (P=80 l/s x3)	set	451,000	1	451,000		0	1	451,000	
		pump for SP01 (P=80 ls x2)		194,000		0	1	194,000	1	194,000	
		PS07: 130 l/s (P=65 l/s x2)	set	169,000	1	169,000		0	1	169,000	
		pump for SP01 (P=80 ls x1)		73,000		0	1	73,000	1	73,000	
		PS08: 100 l/s (P=50 l/s x3)	set	242,000		0	1	242,000	1	242,000	
		PS09: 65 l/s (P=65 l/s x2)	set	121,000		0	1	121,000	1	121,000	
		Total				**1,646,500**		**1,357,000**		**3,003,500**	
3	Construction of Water Treatment Plant	STP1 exp. 8,500m^3/day	set	4,840,000	1	4,840,000		0	1	4,840,000	
		STP1 exp. 25,500m^3/day	set	14,520,000		0	1	14,520,000	1	14,520,000	
		STP2 9,000m^3/day	set	5,445,000		0	1	5,445,000	1	5,445,000	
		Total				**4,840,000**		**19,965,000**		**24,805,000**	
4	Demolition of Existing Sewer Pipes	HCP 300mm - 500mm	m	12	4,000	48,400		0	4,000	48,400	
		CIP 300mm - 500mm	m	12	500	6,050		0	500	6,050	
		Total				**54,450**		**0**		**54,450**	
GRAND TOTAL				-		**10,693,000**		**21,750,350**		**32,443,350**	

Source: JICA Study Team

7. COST ESTIMATE

The total project cost for the infrastructure development is estimated based on direct construction cost of the works estimated in the previous Sections 2 to 6 as follows;

Table 7.1-1 Total Project Cost

(Unit: 1,000 US$)

Description	Phase-I	Phase-II	Total
1. Direct Cost			
Internal Road	42,000	7,571	49,571
Landfill	68,348	119,268	187,616
Drainage works	14,306	5,451	19,757
Water supply works	9,858	4,106	13,964
Power supply works	40,639	49,382	90,021
Sewerage works	10,693	21,750	32,443
Sub-total	185,844	207,528	393,372
Consulting Services	18,584	20,753	39,337
Project Direct Cost	204,428	228,281	432,709
2. Indirect Cost			
Price Escalation (Foreign Portion)	2,396	9,555	11,951
Price Escalation (Local Portion)	23,263	101,614	124,877
Physical Contingency	10,221	11,414	21,635
Import Duties	1,933	2,283	4,216
Value Added Tax	24,302	35,315	59,617
Administration Expenses	1,933	2,283	4,216
Land Acquisition Cost	17,209	25,495	42,704
3. Total Project Cost	286,577	416,239	702,816

Source: JICA Study Team

The following conditions and assumptions are applied in the above estimate.

1) Price Escalation for Foreign Component (FC): 1.7 % of total direct cost of FC
2) Price Escalation for Local Component (LC): 4.0 % of total direct cost of LC
3) Share of Foreign/Local Component: 20-80
4) Physical Contingency: 5.0 % of total direct cost
5) Import Duties: 5.0 % on products to be imported
6) Value Added Tax:10.0 % of total direct cost
7) Administration Expenses:1.0 % of total direct cost

8. IMPLEMENTATION SCHEDULE

After the updating study of Master Plan and its approval, the engineering work including feasibility study, basic design and detailed design will be carried out from 2008 to 2010 for Phase 1. Subsequently, construction work will be commenced in 2010 and completed in 2012. For Phase 2 development, the construction work will be carried out from 2018 to 2020 after the design work completed in 2017.

The Implementation schedule of the HHTP development is shown in the table below;

Table 8.1-1 Implementation Schedule

Description	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
1. Updated Master Plan																		
2. Phase-1 Development (810 ha incl. Stage-1)																		
Feasibility study																		
Fund arrangement																		
Basic Design/Detailed Design																		
Procurement of contractor																		
Construction of common infrastructure																		
Development of functional zones including land preparation																		
Construction of tenant facilities																		
3. Phase-2 Development (800ha)																		
Feasibility study																		
Fund arrangement																		
Basic Design/Detailed Design																		
Procurement of contractor																		
Construction of common infrastructure																		
Development of functional zones including land preparation																		
Construction of tenant facilities																		

Source: JICA Study Team

9. FINANCIAL ANALYSIS

9.1 Presumption of Financial Analysis

(1) Source of Investment

The source of investment for the development of the Project is planned to be a mixture of public and private financial sources of both foreign and local. The public entity organized for the development and operation of HHTP that is Hoa Lac High-tech Park – Management Board (hereinafter referred to as the HHTP-MB) is planned to furnish all necessary common infrastructures such as internal road, drainage, water supply system, sewerage system and power distribution system. While, the infrastructure inside the functional zones except for research and development zone will be developed by the private development company (hereinafter referred to as the HHTP-DC) selected by and contracted with the HHTP-MB.

As for land preparation (or land leveling work), HHTP-MB will at least responsible for Research and Development Zone, and land preparation for other zones will be carried out by HHTP-DC in principle. However, some land preparation work other than Research and Development Zone could be carried out by HHTP-MB in parallel with construction of common infrastructures in order to ensure to maintain the implementation schedule set out in Chapter 8. In this financial analysis, all the land preparation cost is included in the project cost as shown in Table 9.1-3.

The upper structures of the Project are composed of buildings and facilities for research and development, education and training, residence of various type as well as facilities for amenity functions, and factories for manufacturing of high-tech products in the industrial estate, etc.. These buildings and facilities are planned to be financed out from partly public and partly private financial sources. The construction cost of such buildings and facilities is not included in this financial analysis since those are out of scope of this study.

(2) Phased Development Schedule

The Project is planned to be developed in two phases in the period of 2008 to 2012 as the phase-1 of the Project and 2016-2020 as the Phase-2 of the Project, respectively. Table 9.1-1 shows the area of each functional area composing the Project by phase and by type of financial source for the development of upper structures on top of respective land area prepared by the HHTP-MB.

Table 9.1-1 Development Schedule of Area by Phase

(Unit: hectare)

Area		Phase-1	Phase-2	Total	Financial Source
1	High-tech Industrial Area	140	200	340	Private
2	Software Park	45	30	75	Private
4	Residential Zone	15	35	50	Private
5	Housing Complex	0	20	20	Private
6	Education and Training Zone	55	40	95	Private
7	Reserved Area	0	180	180	Private
8	Amenity Zone	100	10	110	Private
9	Research and Development Zone	70	75	145	Public
10	Center of High-tech City	40	10	50	Private/ Public
11	Mixed Use Zone	75	25	100	Private
12	Amusement Zone	20	40	60	Private/ Public
13	Lake and Buffer Zone	140	0	140	Public
14	Common Area for Infrastructure	110	135	245	Public
	Total	810	800	1,610	

Source: JICA Study Team

(3) Financial Scheme of the Project

It is assumed that the development of all necessary common infrastructure is financed mostly by institutional financial source either in the form of long-term soft loan through ODA or other sources and partly by the national budget. All the estate or land prepared by the HHTP-MB except for the land prepared for the public use such as the area prepared for research and development function is planned to be leased out to the HHTP-DC selected by HHTP-MB. In such a case, HHTP-MB will act as a head lesser who leases the land to the HHTP-DC in lot but not piece by piece of land. The HHTP-DC act as a lessee and develop the upper structure by himself or sub-lease the land for further development of upper structures on the leased land by the HHTP-MB to the private HHTP-DC. The revenue being generated through the leasing of the land by the HHTP-MB is considered as a major source of repayment to the loan arranged for the development of those needed infrastructure.

(4) Project Costs for Financial Analysis

The presumption of conditions for the estimation of various cost items other than project direct cost area as tabulated in Table 9.1-2. The development cost of the Project based on those conditions is estimated at around US$ 552 million and its breakdown is as shown in Table 9.1-3.

As for the financial analysis at this stage of the study, the price escalation is not needed to be considered. Because if the construction cost is assumed to increase the land lease price should also be assumed to increase at the same rate of increase of construction cost. In the case, if the escalation of construction cost is assumed and included the total estimated project cost will reach to US$ 700 million which is 1.28 times higher than the estimated project cost in total covering Phase-1 and Phase-2. It is to be noted that there is 3 to 5 years of interval between the completion of Phase-1 and starting of works for the construction of Phase-2.

Table 9.1-2 Conditions Applied for Project Cost Estimation

Factor	Conditions
Share of Foreign/Local Component:	20-80
Physical Contingency:	5.0 % of total direct cost
Import Duties:	5.0 % on products to be imported
Value Added Tax:	10.0 % of total direct cost
Administration Expenses:	1.0 % of total direct cost

Table 9.1-3 Project Cost for Financial Analysis

(Unit: '000 US$)

Description	Phase-I	Phase-II	Total
1. Direct Cost	(2008～12)	(2016～20)	
Internal Road	42,000	7,571	49,571
Landfill	68,348	119,268	187,616
Drainage works	14,306	5,451	19,757
Water supply works	9,858	4,106	13,964
Power supply works	40,639	49,382	90,021
Sewerage works	10,693	21,750	32,443
Sub-total	185,844	207,528	393,372
Consulting Services	18,584	20,753	39,337
Project Direct Cost	204,428	228,281	432,709
2. Indirect Cost			
Physical Contingency	10,221	11,414	21,635
Import Duties	1,933	2,283	4,216
Value Added Tax	21,669	24,198	45,867
Administration Expenses	1,933	2,283	4,216
Land Acquisition Cost	17,209	25,495	42,704
3. Total Project Cost	257,617	293,953	551,570

Source: JICA Study Team

(5) Maintenance Cost

The Management Board develops and furnishes all necessary common infrastructures and undertakes the maintenance of those infrastructures furnished to as well as manage the infrastructure. The cost incurred annually for such management, operation and maintenance is assumed at 0.50% of the total initial capital investment amount or in an order of US$ 1.90 million annually during the project life for Phase-1 and 0.80% of the total initial capital investment amount or in an order of US$ 1.70 million annually for Phase-2 of the Project, respectively. Thus, the total maintenance cost in Phase-2 is estimated at US$ 2.60 million.

(6) Management Cost for the Operation of the Entire Area

The management of the Project will be undertaken by the HHTP-MB as an executing agency of the Project. The estimated cost for the management of the HHTP after the completion of the construction works is estimated at around US$ 0.33 million per year through the life of the Project. It is assumed that the management and administration of the HHTP will be carried out by around 50 personnel of various ranks each assigned and specialized for different kind of business activities.

9.2 Assumed Conditions Applied for Financial Analysis

The conditions applied for the financial analysis to examine the financial viability of the Project are assumed as follows:

(1) Investment plan and period

The investment plan period is defined as the total time period between the start of the cost stream and the end of the cost and benefit stream. The cost stream is defined to start with the final engineering design of the Project. The investment plan period for a project normally extends over a period of 25 – 40 years. In the evaluation of the Project, forty (40) years from the year of commissioning of the Project in total is considered applicable taking into account the scale and type of the project as well as the period of amortization of the long-term loan. During the investment plan period, the cost and benefits are recorded annually over the whole period separately for each benefit and cost components.

(2) Currency

The currency used in the economic evaluation is US Dollar. The exchange rate of Vietnam Dong to the United States Dollar is VND 16,000 and the same of Japanese Yen is ￥120 as of August 2007.

(3) Sale Schedule of Estate

It is assumed that the construction of Phase-1 is completed by 2012 and by the end of 2013 all leasable land is scheduled to be sold out. Likewise, the leasable land prepared as Phase-2 of the Project will be sold out completely by the end of 2021 just subsequent year from the completion of the construction works in 2020.

(4) Rate of Land Lease and Management Charge

The land developed as an industrial estate for high-tech industries that are furnished with a high grade infrastructure meeting with the requirement of high-tech industries plan to build their factories in Vietnam has been leased out to the overseas enterprise for maximum 50 years. In most cases, the land is leased to those tenants in a lamp sum amount calculated based on the offered lease charge per hectare for the remaining years of the maximum year of license given by the government to the industrial estate developer.

The industrial developer or operator further charge to the enterprise those who locate their factory in the industrial estate a charges for covering the cost of maintenance and management of the industrial estate on monthly basis.

The average land lease (rent) charge per hectare and the management charge per hectare per year offered by major industrial estates in Vietnam those have been in operation and attracting a various high-tech industries from abroad is analyzed at US$ 58 /m^2 and US$ 0.080 /m^2/month or US$ 9,600/hectare/year.

The abovementioned average land lease charge is the offer price to the tenant. Therefore, the wholesale price to the industrial estate developer should be lower than this price level at say around 20%. The average land lease charge for development of industrial estate is, therefore, assumed at US$45/$m^2$. The wholesale price of land lease by type of use is assumed as shown in Table 9.2-1. Thereby, the average land lease charge for the Phase-1 of the Project is computed at US$60/$m^2$.

Table 9.2-1 Assumed Land Lease Charge by Type of Use (Phase-1)

Land Use		Area	Unit Price (US$/m2)	Total Amount (US$ Million)
1	High-tech Industrial Area	140	45	63.0
2	Software Park	45	60	33.0
4	Residential Zone	15	100	15.0
5	Housing Complex	0	60	12.0
6	Education and Training Zone	55	40	24.0
7	Reserved Area	0	45	0
8	Amenity Zone	100	100	100.0
9	Research and Development Zone	70	40	16.0
10	Center of High-tech City	40	45	18.0
11	Mixed Use Zone	75	60	45.0
12	Amusement Zone	20	40	0
13	Lake and Buffer Zone	140	0	0
14	Common Area for Infrastructure	110	0	0
	Total Land Area	810		326.0
	Total Salable Area	560		326.0
	Average Land Lease Charge (US$/$m^2$)			60.0

Source: JICA Study Team

As for the financial analysis of the Project, the land lease charge by type of area is assumed at US$ 60/m^2 and the management charge of the infrastructures developed is assumed at US$ 0.080/m^2/month or US$ 9,600/hectare/year, respectively. It is to be noted that the assumed land lease charge per square meter for the high-tech industrial area, which is US$ 45/m^2 equals to the prevailing rate quoted to the developer for high-tech industrial estate in Vietnam. And the management charge assumed is equal to the average management charges of the existing industrial estate in Vietnam.

9.3 Result of Financial Analysis

(1) Computation of Internal Rate of Return

Based on the projected revenue and cost streams, the Financial Internal Rate of Return (FIRR) was computed applying various assumptions for calculation as mentioned in the foregoing paragraph. Table 9.4 shows the result of the financial analysis expressed by

FIRR. <See Annex 9.1 and 9.2 for details>

Table 9.3-1 Result of FIRR Computation

	Phase-1	Phase-1 + Phase-2
FIRR	10.1 %	5.2 %

Source: JICA Study Team

(2) Sensitivity Analysis

The sensitivity analysis of the financial viability of the Project is carried out applying increase and decrease of 10% for respective factors. The result of sensitivity analysis on FIRR is as shown in Table 9.3-2.

Table 9.3-2 Result of Sensitivity Analysis

	Case-1	Case-2	Case-3	Case-4	Case-5
Investment Cost	+ 10%				+ 10%
Revenue (Sale of Estate)		- 10%			
Revenue (Service Charge)			- 10%		
O&M Cost				+ 10%	+ 10%
Phase-1	7.2 %	7.2%	9.6 %	10.1 %	9.6%
Phase-1 + 2	3.9 %	3.2%	4.4 %	5.2 %	2.7 %

Source: JICA Study Team

(3) Marketing Scheme

The total area of land completed with the common infrastructure ready for sale is planned to be sold by HHTP-MB to the HHTP-DC in one lot and in subsequent year of completion of the construction works. The HHTP-DC acquired the land area form HHTP-MB will sub-lease the land to the tenant or develop the upper structure for sale on their account and risk.

(4) Assessment of Capability for Repayment of Loans

The minimum amount of land lease charge in the US Dollar per square meter for maximum 45 years is assessed which makes the borrower of the loan (HHTP-MB) capable to repay the loans based on the following assumptions:

a. Initial capital investment amount: US$ 258 million (Phase-I only)
b. Loan period: 30 years (annual equal installment)
c. Grace period: 10 years
d. Interest rate: 5.0% p.a.
e. Management Charge: US$ 9,600/ha/year (US$ 0.08/m^2/Month)

Table 9.3-3 shows the minimum land lease charge per square meter by the rate of equity share in the initial capital investment and by the interest rate applied to the loan.

As appeared in this table, the larger the equity share (self-finance amount) increase, the smaller the minimum amount. The strategy of marketing the land for lease including its pricing is to be studied carefully taking into consideration of loan conditions in terms of financial source, interest rate, currency, amortization period, grace period, etc.

Table 9.3-3 Minimum Land Lease Charge

	Unit	Case-A	Case-B	Case-C
Share of Equity	%	40%	50%	60%
Share of Loan	%	60%	50%	40%
Amount of Equity	US$ Million	103	129	155
Amount of Loan	US$ Million	155	129	103
Minimum Amount	US$/$m^2$	67	52	37

Source: JICA Study Team

The repayment capability for the loan by the Project is examined as above. When the minimum land lease charge is US$60/m2, the equity share should be around 45% with an interest rate at 5% as in the Case-B.

(5) Cut-off Rate

The Project can be considered as financially feasible if the Financial Internal Rate of Return (FIRR) of the Project can be computed at more than the interest rate of loan assumed to be applied. The standard cut-off rate often referred to for the development project n the developing countries, of which loan is arranged by the international financial source, is LIBOR. The latest LIBOR is around 8.5% in the case the loan is based on US Dollar, but the international financial institutions such as Asian Development Bank offer somewhat lower rate than LIBOR based on the mixture of currency. In such case, the lending rate down to 5.0%.

The cut-off rate applied for the evaluation of the Project's financial viability is assumed at 5.0% as minimum when an institutional financial assistance program is considered for financing of the project and 8.5% when commercial loan is considered for financing of the Project.

9.4 Result of Computation of Financial Viability Indicators

Result of Computation of Financial Viability Indicator: The Project is deemed as viable in view of financial viability as the FIRR of Phase-1 is computed at 10.1% and Phase-1 and 2 combined is computed at 5.2%, both of which are more than the predetermined cut-off rate that is set at 5.0%. Therefore, the Project is considered as feasible subject to that the assumed condition of leasing out of the land and collection of management charges are realized as planned hereto. In other words, if the rate of leasing of land and management charges assumed hereto is not accepted by the developer as the minimum rate, then the financial feasibility of the Project could be lost.

However, if the loan is based on commercial conditions the Project is not financially viable because when the Phase-1 and Phase-2 is combined the FIRR is computed as less than the cut-off rate of 8.5%, which is predetermined considering the loan is based on commercial lending.

Marketability of the Leasable Land: Although the financial viability indicators suggest that the Project is financially viable, the basic assumption of such viability is in question. The most important question is whether the average rate of lease planned at US$ 60/m^2 which is the minimum rate assuring the financial viability, is acceptable to the developer who would undertake the completion of the leased land to the final shape meeting with the requirement of tenants or lessees. As in the case of the sale of industrial estate for high-tech industries, HHTP-MB has approved and has been offering the land lease at about US$ 20/m^2 to the prominent lessees for high-tech industries at present. However, due to a current situation of insufficient infrastructure not many potential investors have been attracted to enter the HHTP even at this quite low level of offered price for leasing of the land. The efforts of marketing of HHTP at the assumed level of land lease rate and management charge to the developer should be made as discussed in the report hereof..

Measures to Make the Project's Financial Viability More Robust: The financial analysis of the Project is carried out aiming to find out the minimum rate of land lease rate and management charges to make the Project financially feasible. Table 9.4-1 shows those rate and conditions to be realized.

Table 9.4-1 Recommended Minimum Rate of Land Lease and Management Charge

Article	Minimum Rate	Note
Land lease for Industrial Zone	US$ 45/m^2	This rate of land lease is the rate for developer. The developer would add some more on top of this rate to cover their expenses to lease the land to their tenant in complete form. The prevailing rates offered to the tenants in Vietnam ranges from US$ 30 to US$ 80 depend on the grade and location of industrial estate.
Management Charge	US$ 9,600/hectare/Year or US$0.08/$m^2$/Month	The prevailing management charge which is aimed at to cover the expenses of maintenance cost of relevant infrastructures of industrial estates in Vietnam at present, ranges from US$ 7,000 to US$ 9,600/hectare/Year depend on the grade and location of industrial estate.

If these rates are not acceptable by the developers or by the tenants searching or selecting the industrial estate for their business operation, then, these charges are to be reduced somewhat. In such a case, the Government of Vietnam is to cover the difference of two rates as the minimum rates to be secured for the maintenance of the financial viability of the Project and the acceptable rates of prominent developer or tenants those demand the lower rates.

There are three measures which the government could support the Project financially as follows:

1) Subsidy for the land lease

   The government will provide some subsidy for the land lease by the HHTP-MB to the developer. As a matter of fact the land lease rate offered by HHTP at present is about US$ 20/m^2, which is quite low. Due to the current conditions of HHTP even this rate does not attract the potential tenants substantially. It is expected that the new rate will be accepted by the tenants if the needed infrastructure inside and outside of the Project, however, the necessity of such subsidy should be considered. In the financial analysis, the rate of land lease charge is assumed at US$45/$m^2$, which equals the average land lease charge in Vietnam for the high-tech industrial estate.

2) Subsidy for the management charge

   The government will provide some subsidy for the management charge or provide budget for the maintenance of the infrastructure.

3) Purchase of land for research and development activities

   The area for research and development are planned to be leased out to the government agencies. However, if this land allotted for such purpose is leased out or sold to these government agencies without any charge, it will be very attractive to those institute..

Table 9.4-2 suggests the necessary amount of budget to cover such expenditure of the government in related to the Project.

Table 9.4-2 Amount of Government Expenditure

Article	Rate of Subsidy	Amount	Note
Land lease (Industrial Zone)	US$ 25/m^2 (=US$ 45/m^2-20/m^2)	US$ 35 million	For industrial estate zone and Phase-1 only (140 ha x US$ 25/m^2= US$35 million)
Land lease (R&D Zone)	US$ 40/m^2	US$ 16 million	For R&D zone and Phase-1 only (40 ha x US$ 40/m^2= US$16 million)

As the Project is planned to be fully operative at the level which is quite competitive against other industrial estate operating or under construction in other area in and around Hanoi or in Ha Tay province at present, the assumed rate of land lease and management charge could be attractive to the developer and the tenant in the future. Therefore, such subsidy or financial support by the government may not be required to make the project's financial performance better or viable throughout the project life. However, the study on supporting the needed finance of the Project by the government of Vietnam is to be thoroughly conducted.

Annex 9.1

Financial Viability Indicator Computation

Phase-I **FIRR** **10.1%**

Phase-I	Year	Investment	O&M	Total Expend.	Estate Sold	Management Charge	Total Revenue	Cash-flow
	2008	21.58		21.58				-21.58
	2009	8.74		8.74				-8.74
	2010	129.05		129.05				-129.05
	2011	68.43		68.43				-68.43
	2012	29.82		29.82				-29.82
1	2013		2.26	2.26	312.70	4.42	317.12	314.86
2	2014		2.26	2.26	0.00	4.42	4.42	2.16
3	2015		2.26	2.26	0.00	4.42	4.42	2.16
4	2016		2.26	2.26	0.00	4.42	4.42	2.16
5	2017		2.26	2.26	0.00	4.42	4.42	2.16
6	2018		2.26	2.26	0.00	4.42	4.42	2.16
7	2019		2.26	2.26	0.00	4.42	4.42	2.16
8	2020		2.26	2.26	0.00	4.42	4.42	2.16
9	2021		2.26	2.26	0.00	4.42	4.42	2.16
10	2022		2.26	2.26	0.00	4.42	4.42	2.16
11	2023		2.26	2.26	0.00	4.42	4.42	2.16
12	2024		2.26	2.26	0.00	4.42	4.42	2.16
13	2025		2.26	2.26	0.00	4.42	4.42	2.16
14	2026		2.26	2.26	0.00	4.42	4.42	2.16
15	2027		2.26	2.26	0.00	4.42	4.42	2.16
16	2028		2.26	2.26	0.00	4.42	4.42	2.16
17	2029		2.26	2.26	0.00	4.42	4.42	2.16
18	2030		2.26	2.26	0.00	4.42	4.42	2.16
19	2031		2.26	2.26	0.00	4.42	4.42	2.16
20	2032		2.26	2.26	0.00	4.42	4.42	2.16
21	2033		2.26	2.26	0.00	4.42	4.42	2.16
22	2034		2.26	2.26	0.00	4.42	4.42	2.16
23	2035		2.26	2.26	0.00	4.42	4.42	2.16
24	2036		2.26	2.26	0.00	4.42	4.42	2.16
25	2037		2.26	2.26	0.00	4.42	4.42	2.16
26	2038		2.26	2.26	0.00	4.42	4.42	2.16
27	2039		2.26	2.26	0.00	4.42	4.42	2.16
28	2040		2.26	2.26	0.00	4.42	4.42	2.16
29	2041		2.26	2.26	0.00	4.42	4.42	2.16
30	2042		2.26	2.26	0.00	4.42	4.42	2.16
31	2043		2.26	2.26	0.00	4.42	4.42	2.16
32	2044		2.26	2.26	0.00	4.42	4.42	2.16
33	2045		2.26	2.26	0.00	4.42	4.42	2.16
34	2046		2.26	2.26	0.00	4.42	4.42	2.16
35	2047		2.26	2.26	0.00	4.42	4.42	2.16
36	2048		2.26	2.26	0.00	4.42	4.42	2.16
37	2049		2.26	2.26	0.00	4.42	4.42	2.16
38	2050		2.26	2.26	0.00	4.42	4.42	2.16
39	2051		2.26	2.26	0.00	4.42	4.42	2.16
40	2052		2.26	2.26	0.00	4.42	4.42	2.16
		257.6	90.3	348.0	312.7	176.6	489.3	141.4

Annex 9.2

Financial Viability Indicator Computation

Phase-1 + Phase-2 **FIRR 5.2%**

Phase-I	Phase-II	Year	Investment	O&M	Total Expend.	Estate Sold	Management Charge	Total Revenue	Cash-flow
		2008	21.58		21.58				-21.58
		2009	8.74		8.74				-8.74
		2010	129.05		129.05				-129.05
		2011	68.43		68.43				-68.43
1		2012	29.82		29.82				-29.82
2		2013	0	2.26	2.26	312.70	4.42	317.12	314.86
3		2014	0	2.26	2.26	0.00	4.42	4.42	2.16
4		2015	0	2.26	2.26	0.00	4.42	4.42	2.16
5		2016	30.38	2.26	32.63	0.00	4.42	4.42	-28.22
6		2017	9.76	2.26	12.02	0.00	4.42	4.42	-7.60
7		2018	185.44	2.26	187.70	0.00	4.42	4.42	-183.28
8		2019	45.18	2.26	47.44	0.00	4.42	4.42	-43.02
9		2020	23.20	2.26	25.46	0.00	4.42	4.42	-21.04
10	1	2021		3.95	3.95	191.31	10.27	201.59	197.64
11	2	2022		3.95	3.95	0.00	10.27	10.27	6.32
12	3	2023		3.95	3.95	0.00	10.27	10.27	6.32
13	4	2024		3.95	3.95	0.00	10.27	10.27	6.32
14	5	2025		3.95	3.95	0.00	10.27	10.27	6.32
15	6	2026		3.95	3.95	0.00	10.27	10.27	6.32
16	7	2027		3.95	3.95	0.00	10.27	10.27	6.32
17	8	2028		3.95	3.95	0.00	10.27	10.27	6.32
18	9	2029		3.95	3.95	0.00	10.27	10.27	6.32
19	10	2030		3.95	3.95	0.00	10.27	10.27	6.32
20	11	2031		3.95	3.95	0.00	10.27	10.27	6.32
21	12	2032		3.95	3.95	0.00	10.27	10.27	6.32
22	13	2033		3.95	3.95	0.00	10.27	10.27	6.32
23	14	2034		3.95	3.95	0.00	10.27	10.27	6.32
24	15	2035		3.95	3.95	0.00	10.27	10.27	6.32
25	16	2036		3.95	3.95	0.00	10.27	10.27	6.32
	17	2037		3.95	3.95	0.00	10.27	10.27	6.32
	18	2038		3.95	3.95	0.00	10.27	10.27	6.32
	19	2039		3.95	3.95	0.00	10.27	10.27	6.32
	20	2040		3.95	3.95	0.00	10.27	10.27	6.32
	21	2041		3.95	3.95	0.00	10.27	10.27	6.32
	22	2042		3.95	3.95	0.00	10.27	10.27	6.32
	23	2043		3.95	3.95	0.00	10.27	10.27	6.32
	24	2044		3.95	3.95	0.00	10.27	10.27	6.32
	25	2045		3.95	3.95	0.00	10.27	10.27	6.32
	26	2046		3.95	3.95	0.00	10.27	10.27	6.32
	27	2047		3.95	3.95	0.00	10.27	10.27	6.32
	28	2048		3.95	3.95	0.00	10.27	10.27	6.32
	29	2049		3.95	3.95	0.00	10.27	10.27	6.32
	30	2050		3.95	3.95	0.00	10.27	10.27	6.32
	31	2051		3.95	3.95	0.00	10.27	10.27	6.32
	32	2052		3.95	3.95	0.00	10.27	10.27	6.32
	Total		551.57	144.41	695.98	504.01	364.03	868.05	172.06

10. ECONOMIC ANALYSIS

This chapter presents the results of the evaluation of the economic feasibility of implementing the Hoa Lak High-tech Park Development Project. It is concerned with the determination of the net benefits that will accrue to the economy as a result of the project. Only tangible costs and benefits are considered in evaluation.

10.1 Methodology

The relevant economic feasibility criterion is derived from a procedure aimed at maximizing the overall objectives of the national economy. Economic feasibility is measured by comparing the Economic Internal Rate of Return (EIRR) of the project for infrastructure project as a minimum 12% which are considered by Asian Development Bank and other international financial institutions. This 12 percent discount rate is used as the economic opportunity cost of capital, thus, to calculate B/C, NPV and EIRR.

(1) Cost

The project costs for the Project from 2008 to 2020 covering the period of Phase-1 and Phase-2 of the Project was estimated firstly on the basis of the market price as financial costs and it is converted to the economic costs for the economic analysis. As for the economic analysis, it is assumed that the Project is owned and operated fully by the public entity. The monetary unit shown therein, therefore, is based on prevailing market prices of required goods and services at present August 2007. Taxes composed of the current tax and import duties are subtracted as transfer payment from the total financial cost estimated. Tax rates applied for this subtraction were 10 % as value added tax on all prices estimated for local components and 5 % as import duties on all prices estimated for foreign components. The land acquisition as well as administration cost of the Project are also subtracted.

(2) Benefits

The benefits are estimated based on the comparison of the With the Project Case and Without the Project Case. The quantifiable benefits applied for the economic analysis are as follows:

1. Benefits derived from the difference of output from the industrial estate of standard or rather low level industrial products and high-tech products;
2. Benefits derived from multiplier effect of investment for high-tech industry which enhances the development and investment to related industries that produce the component, part and other materials required for the production of high-tech products; and
3. Benefits derived from the application of results of research and development activities taken place in HHTP.

10.2 Assumed Conditions for Economic Analysis

Before the economic evaluation is carried out and various inputs factors determined, the framework has to be established and defined. The data framework consists of the following components.

1. Composition of direct cost

   The direct cost estimated for the Project in 2007 is presented in Table 9.3. The cost estimated based on the market price is converted firstly into the economic cost by subtracting tax, import duties, administration expenses, and land acquisition cost which is accounted for around 30% of the direct cost. Then the subtracted cost is converted into economic cost using the standard conversion factor at 10%.

2. Composition of benefits due to increase of productivity

   The average output per hectare of industrial estate developed and operating in Vietnam in 2005 is estimated at US$ 0.90 million per year. It was US$ 0.70 million per year in 2000. The reason of this increased output is thought to be attributed by an increased output from the manufacturing activity of high-tech industries especially located in the industrial estate. Based on this estimated value per hectare of industrial estate the difference between the value of standard industrial estate and high-tech industrial estate is guessed as US$ 0.20 million. This suggest that the expansion of manufacturing activity for high-tech products will generate US$ 0.20 million per hectare of industrial estate per year than the manufacturing activity of standard non-high-tech products. This difference of value of output between standard non-high-tech product and high-tech product is considered as the basic economic benefit attributed by the execution of the Project.

   In general, the high-tech industrial activity is supported by various related industries such as supply of needed components, parts, software, raw materials, logistic services, transport, etc. from local manufactures in or out of the industrial estate where the high-tech industry is located. Therefore, the investment for the high-tech industry generates the investments and increases the industrial activities of related industries supporting the high-tech manufacturing activity. This is called a multiplier effect of the investment in one sector to the other related sector. However, such multiplier effect can only be measured if there exist In-put and Out-put Table (I-O Table) authorized by the government agency concerned to the macro economic management of the country. In Vietnam, I-O Table does not exist at present the multiplier effect due to an investment in the high-tech industrial activity is guessed at 1.20 at least.

3. Composition of benefits due to investment in FDI

   The incremental capital-output ratio (ICOR)[1] of FDI for high-tech industry is measured based on the data available for both GDP and FDI on high-tech industrial sector in the period of 2001-2005. The ICOR of the same is computed at 2.3, which is quite high. This result of analysis supports the multiplier effect of investment of FDI to high-tech industry at 1.20 as the minimum rate.

[1] Incremental Capital-Output Ratio: Ratio of GDP growth divided by the growth of investment in one sector.

4. Composition of benefits due to R&D

   The theoretical linking with foreign direct investment to economic growth is well known. The trans national corporation those composes the major part of FDI has been actively progress the internationalization of R&D so as to compete among them in all over the world in general but in ASEAN countries in particular. There is a positive correlation between R&D intensity and productivity grown. The output elasticity to R&D development is estimated at 0.10 to 0.50 depending on the sector and timing[2]. There is also a positive correlation between investment in R&D and the quality of the human capital, which ultimately adds to the significance of the technological progress term in the production function. The average share of investment on R&D accounts around 2.5% in OECD member countries. It is estimated that an increase of 1% of investment in R&D results on increased productivity at 0.46 point. The public investment on R&D in Vietnam in 2005 was 0.53% of GDP and it has been expanded to 1% of GDP in 2006. The amount of investment on R&D will be enhanced and accelerated due to the implementation of the Project. Therefore the elasticity of investment on R&D could reach to more than 0.40 point.

5. Multiplier Effect

   The multiplier effect of investment in FDI high-tech sector is determined at 1.50 taking into consideration of estimated rate of simple multiplier effect of high-tech industry to other industries, ICOR and economic effect of R&D in combination.

10.3 Result of Economic Analysis

The economic viability indicators computed are as shown in Table-10.1. <See Annex 10.1 and 10.2 for details>

Table 10.3-1 Result of Economic Analysis

	EIRR	NPV	B/C	Discount Rate
Phase-1	16.0%	US$ 33.2 million	1.22	12%
Phase-1+2	14.6%	US$ 29.8 million	1.12	12%

The social economic opportunity cost of Vietnam is considered at 12% as Asian Development Bank and other international financial institution often uses this rate for evaluation of the infrastructure development project not only in Vietnam but also in other ASEAN countries. Therefore, 12% is set at the cut-off rate to measure the project viability.

10.4 Evaluation of Economic Viability

The EIRR is computed as 16.5% for Phase-1 and 17.3% for combination of Phase-1 and Phase-2, both of which is more than the cut-off rate predetermined. NPV computed is positive and B/C is more than 0. Therefore, the Project is considered as viable and competitive from the economic analysis point of view.

[2] Industrial R&D Economic and Policy Analysis Report 2006. European Commission

Annex 10.1

Economic Analysis

Conversion Factor Phase-1 74 Phase-2 71

EIRR **16.0%** **NPV** **33.2** Million **B/C** **1.22** **Discount Rate** **12%**

Year	Calendar Year	IE Area	Capital Investment	O&M	Cost Total	Economic Benefit per	Multiplier Effect	Economic Benefit	Balance	Discount	Cost	Benefit
	2008		15.97		15.97				-15.97	1.000	16.0	0.0
	2009		6.47		6.47				-6.47	0.880	5.7	0.0
	2010		95.47		95.47				-95.47	0.774	73.9	0.0
	2011		50.62		50.62				-50.62	0.681	34.5	0.0
	2012		22.06		23.48				-23.48	0.600	14.1	0.0
	2013	140		1.42	1.42	0.20	1.50	42.00	40.58	0.528	0.8	22.2
	2014	140		1.42	1.42	0.20	1.50	42.00	40.58	0.464	0.7	19.5
	2015	140		1.42	1.42	0.20	1.50	42.00	40.58	0.409	0.6	17.2
1	2016	140		1.42	1.42	0.20	1.50	42.00	40.58	0.360	0.5	15.1
2	2017	140		1.42	1.42	0.20	1.50	42.00	40.58	0.316	0.5	13.3
3	2018	140		1.42	1.42	0.20	1.50	42.00	40.58	0.279	0.4	11.7
4	2019	140		1.42	1.42	0.20	1.50	42.00	40.58	0.245	0.3	10.3
5	2020	140		1.42	1.42	0.20	1.50	42.00	40.58	0.216	0.3	9.1
6	2021	140		1.42	1.42	0.20	1.50	42.00	40.58	0.190	0.3	8.0
7	2022	140		1.42	1.42	0.20	1.50	42.00	40.58	0.167	0.2	7.0
8	2023	140		1.42	1.42	0.20	1.50	42.00	40.58	0.147	0.2	6.2
9	2024	140		1.42	1.42	0.20	1.50	42.00	40.58	0.129	0.2	5.4
10	2025	140		1.42	1.42	0.20	1.50	42.00	40.58	0.114	0.2	4.8
11	2026	140		1.42	1.42	0.20	1.50	42.00	40.58	0.100	0.1	4.2
12	2027	140		1.42	1.42	0.20	1.50	42.00	40.58	0.088	0.1	3.7
13	2028	140		1.42	1.42	0.20	1.50	42.00	40.58	0.078	0.1	3.3
14	2029	140		1.42	1.42	0.20	1.50	42.00	40.58	0.068	0.1	2.9
15	2030	140		1.42	1.42	0.20	1.50	42.00	40.58	0.060	0.1	2.5
16	2031	140		1.42	1.42	0.20	1.50	42.00	40.58	0.053	0.1	2.2
17	2032	140		1.42	1.42	0.20	1.50	42.00	40.58	0.047	0.1	2.0
18	2033	140		1.42	1.42	0.20	1.50	42.00	40.58	0.041	0.1	1.7
19	2034	140		1.42	1.42	0.20	1.50	42.00	40.58	0.036	0.1	1.5
20	2035	140		1.42	1.42	0.20	1.50	42.00	40.58	0.032	0.0	1.3
21	2036	140		1.42	1.42	0.20	1.50	42.00	40.58	0.028	0.0	1.2
22	2037	140		1.42	1.42	0.20	1.50	42.00	40.58	0.025	0.0	1.0
23	2038	140		1.42	1.42	0.20	1.50	42.00	40.58	0.022	0.0	0.9
24	2039	140		1.42	1.42	0.20	1.50	42.00	40.58	0.019	0.0	0.8
25	2040	140		1.42	1.42	0.20	1.50	42.00	40.58	0.017	0.0	0.7
26	2041	140		1.42	1.42	0.20	1.50	42.00	40.58	0.015	0.0	0.6
27	2042	140		1.42	1.42	0.20	1.50	42.00	40.58	0.013	0.0	0.5
28	2043	140		1.42	1.42	0.20	1.50	42.00	40.58	0.011	0.0	0.5
29	2044	140		1.42	1.42	0.20	1.50	42.00	40.58	0.010	0.0	0.4
30	2045	140		1.42	1.42	0.20	1.50	42.00	40.58	0.009	0.0	0.4
31	2046	140		1.42	1.42	0.20	1.50	42.00	40.58	0.008	0.0	0.3
32	2047	140		1.42	1.42	0.20	1.50	42.00	40.58	0.007	0.0	0.3
33	2048	140		1.42	1.42	0.20	1.50	42.00	40.58	0.006	0.0	0.3
34	2049	140		1.42	1.42	0.20	1.50	42.00	40.58	0.005	0.0	0.2
35	2050	140		1.42	1.42	0.20	1.50	42.00	40.58	0.005	0.0	0.2
36	2051	140		1.42	1.42	0.20	1.50	42.00	40.58	0.004	0.0	0.2
37	2052	140		1.42	1.42	0.20	1.50	42.00	40.58	0.004	0.0	0.2
	Total		190.59	56.92	248.93	8.00	60.00	1680.00	1431.07		150.39	183.59

Annex 10.2

Economic Analysis

Conversion Factor Phase-1 74 Phase-2 71

EIRR **14.6%** **NPV** **29.8** Million **B/C** **1.12** **Discount Rate** **12%**

Year	Calendar Year	IE Area	Capital Investment	O&M	Cost Total	Economic Benefit per	Multiplier Effect	Economic Benefit	Balance	Discount	Cost	Benefit
	2008		15.97		15.97				-15.97	1.000	16.0	0.0
	2009		6.47		6.47				-6.47	0.880	5.7	0.0
	2010		95.47		95.47				-95.47	0.774	73.9	0.0
	2011		50.62		50.62				-50.62	0.681	34.5	0.0
	2012		22.06		23.48				-23.48	0.600	14.1	0.0
	2013	140	22.47	1.42	23.90	0.20	1.50	42.00	18.10	0.528	12.6	22.2
	2014	140	7.22	1.42	8.65	0.20	1.50	42.00	33.35	0.464	4.0	19.5
	2015	140	137.19	1.42	138.61	0.20	1.50	42.00	-96.61	0.409	56.6	17.2
1	2016	140	32.18	1.42	33.60	0.20	1.50	42.00	8.40	0.360	12.1	15.1
2	2017	140	16.53	1.42	17.95	0.20	1.50	42.00	24.05	0.316	5.7	13.3
3	2018	140	0.00	1.42	1.42	0.20	1.50	42.00	40.58	0.279	0.4	11.7
4	2019	140	0.00	1.42	1.42	0.20	1.50	42.00	40.58	0.245	0.3	10.3
5	2020	140	0.00	1.42	1.42	0.20	1.50	42.00	40.58	0.216	0.3	9.1
6	2021	325		2.49	2.49	0.20	1.50	97.50	95.01	0.190	0.5	18.5
7	2022	325		2.49	2.49	0.20	1.50	97.50	95.01	0.167	0.4	16.3
8	2023	325		2.49	2.49	0.20	1.50	97.50	95.01	0.147	0.4	14.3
9	2024	325		2.49	2.49	0.20	1.50	97.50	95.01	0.129	0.3	12.6
10	2025	325		2.49	2.49	0.20	1.50	97.50	95.01	0.114	0.3	11.1
11	2026	325		2.49	2.49	0.20	1.50	97.50	95.01	0.100	0.2	9.8
12	2027	325		2.49	2.49	0.20	1.50	97.50	95.01	0.088	0.2	8.6
13	2028	325		2.49	2.49	0.20	1.50	97.50	95.01	0.078	0.2	7.6
14	2029	325		2.49	2.49	0.20	1.50	97.50	95.01	0.068	0.2	6.7
15	2030	325		2.49	2.49	0.20	1.50	97.50	95.01	0.060	0.1	5.9
16	2031	325		2.49	2.49	0.20	1.50	97.50	95.01	0.053	0.1	5.2
17	2032	325		2.49	2.49	0.20	1.50	97.50	95.01	0.047	0.1	4.5
18	2033	325		2.49	2.49	0.20	1.50	97.50	95.01	0.041	0.1	4.0
19	2034	325		2.49	2.49	0.20	1.50	97.50	95.01	0.036	0.1	3.5
20	2035	325		2.49	2.49	0.20	1.50	97.50	95.01	0.032	0.1	3.1
21	2036	325		2.49	2.49	0.20	1.50	97.50	95.01	0.028	0.1	2.7
22	2037	325		2.49	2.49	0.20	1.50	97.50	95.01	0.025	0.1	2.4
23	2038	325		2.49	2.49	0.20	1.50	97.50	95.01	0.022	0.1	2.1
24	2039	325		2.49	2.49	0.20	1.50	97.50	95.01	0.019	0.0	1.9
25	2040	325		2.49	2.49	0.20	1.50	97.50	95.01	0.017	0.0	1.6
26	2041	325		2.49	2.49	0.20	1.50	97.50	95.01	0.015	0.0	1.4
27	2042	325		2.49	2.49	0.20	1.50	97.50	95.01	0.013	0.0	1.3
28	2043	325		2.49	2.49	0.20	1.50	97.50	95.01	0.011	0.0	1.1
29	2044	325		2.49	2.49	0.20	1.50	97.50	95.01	0.010	0.0	1.0
30	2045	325		2.49	2.49	0.20	1.50	97.50	95.01	0.009	0.0	0.9
31	2046	325		2.49	2.49	0.20	1.50	97.50	95.01	0.008	0.0	0.8
32	2047	325		2.49	2.49	0.20	1.50	97.50	95.01	0.007	0.0	0.7
33	2048	325		2.49	2.49	0.20	1.50	97.50	95.01	0.006	0.0	0.6
34	2049	325		2.49	2.49	0.20	1.50	97.50	95.01	0.005	0.0	0.5
35	2050	325		2.49	2.49	0.20	1.50	97.50	95.01	0.005	0.0	0.5
36	2051	325		2.49	2.49	0.20	1.50	97.50	95.01	0.004	0.0	0.4
37	2052	325		2.49	2.49	0.20	1.50	97.50	95.01	0.004	0.0	0.4
	Total		406.18	90.98	498.58	8.00	60.00	3456.00	2957.42		240.13	269.90