8. Implementation Program of Sewerage Development

8.1 Prioritization

Priority sequences for implementation of the sewerage developments are determined based on the aspects of demand/benefits, adverse effects and constraints of the respective development projects.

Demand/benefits consist of population density, public land use rate, pollution load generation and reduction of water-borne disease contraction rate. Adverse effects are represented by construction cost and O/M costs of the project.

Constraints consists of affordability of sewerage development and availability of treatment plant site.

8.1.1 Demand and Benefit of Sewerage Development

(1) Population Density

Population density is the typical index representative to sewerage development requirement.

Average future population density of nine (9) sewerage development zones is 304 person/ha.

High population density area has higher priority for sewerage development because of high pollution load generation and relatively worse unsanitary condition, in principle.

The priority by population density is defined as follows;

Priority	Index	Net Population Density (person/ha)	
		Existing	Future
Highest	5	Over 500	Over 500
Second	4	Over 250	Over 300
Medium	3	-	Over 300
Low	2	-	less than 299
Lowest	1	-	less than 200

Population density and the assigned priority index of each sewerage zone is shown below.

Sewerage Zone	Net Population Density (person/ha)		Priority Index
	Existing	Future	
THBNDT	479	454	5
NLTN	309	346	4
THLG	222	268	4
TLBC	124	237	3
SW	82	336	3
Single Symbol	79	275	3
SN-I	74	215	2
SN-II	55	171	1
SE	40	355	3

(2) Public Land Use

Ratio of commercial and institutional area to the total sewerage development area is defined as public land use rate. Higher priority for sewerage development will be given to a zone with high public land use rate.

Public land use rate of each sewerage development zone is shown below along with the priority index.

Sewerage Zone	Public Land Use	Priority Index
THBNDT	14.8	5
NLTN	14.3	5
THLG	1.6	1
TLBC	13.3	4
SW	11.7	4
Single Symbol	1	1
SN-I	2.4	1
SN-II	8.2	3
SE	0.2	1

(3) Pollution Load Generation

Sewerage development contributes the abatement pollution load discharging public water bodies with no treatment. Higher priority for sewerage development will be given a zone with high pollution load generation.

Pollution load generation of each sewerage development zone in 2020 is estimated below along with the priority index.

Sewerage Zone	Pollution Load Generation in BOD (kg/day)		Priority Index
	Existing	Future	
THBNDT	58,748	83,417	5
NLTN	48,690	81,574	5
THLG	21,684	39,332	3
TLBC	7,428	21,291	2
SW	3,422	17,910	1
SS	3,216	14,400	1
SN-I	5,991	22,500	2
SN-II	2,219	8,843	1
SE	2,384	27,000	2

(4) Water-borne Disease Contraction Rate

Regional distribution of water-borne disease contraction rate is dealt in Chapter D.

Average annual regional water-borne disease contraction rate in each sewerage development zone is shown below together with priority index.

Sewerage Zone	Water-borne Disease Contraction Rate/10,000	Priority Index
THBNDT	19.07	4
NLTN	12.68	3
THLG	22.01	5
TLBC	12.33	3
SW	10.51	3
Single Symbol	9.45	2
SN-I	24.19	5
SN-II	9.88	2
SE	7.88	1

8.1.2 Adverse Effects

(1) Construction Cost

The break-down of project cost by each sewerage zone is presented in Table F.8.1.

Unit construction cost per future service population of each sewerage zone ranges from 2.9 million VND/person in THBNDT zone to 8.7 million VND/person in SN-II zone.

A zone with unit construction cost higher than 7 million VND is assigned lowest priority and lower than 3 million VND is assigned highest priority index.

Unit construction cost of each sewerage zone is shown below along with the priority index.

Sewerage Zone	Unit Construction Cost/Service Population (VND)	Priority Index
THBNDT	2,932,067	5
NLTN	3,496,182	4
THLG	3,727,156	4
TLBC	3,640,340	4
SW	5,802,010	3
SS	7,184,375	1
SN-I	6,423,200	2
SN-II	8,724,682	1
SE	5,079,833	3

(2) Operation and Maintenance Cost

Unit annual O/M cost per service population of each sewerage zone ranges from 18,578 VND/person in THBNDT zone to 41,550 VND/person in SS zone.

Unit annual O/M cost per service population is higher than 35,000 VND is assigned as the lowest priority zone and lower than 20,000 VND is the highest priority zone.

Unit annual O/M cost of each sewerage zone is shown below along with the priority index.

Sewerage Zone	Unit Annual O/M Cost/Service Population (VND/annum/person)	Priority Index
THBNDT	18,578	5
NLTN	23,001	4
THLG	24,288	4
TLBC	24,937	4
SW	24,178	2
SS	41,550	1
SN-I	27,784	2
SN-II	37,099	1
SE	19,738	3

8.1.3 Constraints

(1) Affordability

Financial viability of the project depends on affordability of the users. Higher priority will be given to a zone with a higher affordability of the users.

Willingness to pay for the sewerage development of each sewerage development zone is shown below along with the priority index.

Sewerage Zone	Willingness to Pay for Sewerage Development (VND/ha)	Priority Index
THBNDT	595,546	5
NLTN	323,574	3
THLG	285,613	3
TLBC	86,987	2
SW	23,757	1
SS	56,351	2
SN-I	50,548	2
SN-II	35,003	1
SE	27,246	1

(2) Treatment Plant Site Availability

For the sewage treatment plant site, only NLTN zone has a difficulty to get own treatment plant site near-by. Other eight (8) sewerage development zones can acquire their own treatment plant sites near their service area. Then, NLTN zone has lower priority index from the availability of treatment plant site.

8.1.4 Integration of Priority Index

From the integration of above mentioned priority index, THBNDT zone is determined as the highest priority project with priority index of 40, and the second one is NLTN zone of 30 points, third one is THLG of 29 points and the lowest is SS zone of 16 points.

The integrated priority index of each sewerage zone is shown below.

Sewerage Zone	Integrated Priority Index
THBNDT	39
NLTN	30
THLG	29
TLBC	27
SW	22
SS	16
SN-I	21
SN-II	15
SE	19

8.2 Implementation Program

Since respective nine (9) sewerage zones do not intersect each other, the implementation program is established according to the descending order of priority sequences of each zone, independently. Implementation is planed to commence in the year 2000 and be completed in the year 2020.

A total construction period of six (6) years is assigned for THBNDT zone, consisting of initial one (1) year for engineering design and land acquisition program as required and the remaining five (5) years for construction works.

The second priority zone of NLTN will be commenced in the year of 2003 and be completed in the year 2008. The proposed implementation program of the project is shown in Fig. F.8.1.

Based on the implementation program, disbursement schedule is formulated as shown in Table F.8.2. Total project cost for nine (9) sewerage development projects is VND 25,146.9 billion at 1999 prices and required annual investment cost ranges from VND 134.5 billion to VND 1,828.5 billion with an average of VND 1,197.5 billion.

9. Evaluation of Future River/Canal Quality

All the major rivers and canals in HCMC have been severely polluted by untreated domestic and industrial wastewater and solid wastes from houses and industrial estates.

A study of evaluating water quality in terms of BOD_5 of major rivers and canals in the year 2020 is carried out for the following cases.

- Case I: If the present situation continues, leaving both of untreated domestic and industrial wastewater discharge to rivers and canals.
- Case II: If only industrial wastewater is discharged to rivers/canals after appropriate treatment to the level of the discharge standard, leaving domestic wastewater discharge to rivers and canals without any treatment.
- Case III: If proposed sewerage system are completely developed and river/canal bed deposit is removed.

The evaluation is carried out under the conditions as follows.

- Unit pollution load from domestic source is based on the figures in this chapter.
- Unit water consumption by industries is to be 60 m^3/ha/day in 1997 and 80 m^3/ha/day in 2020.
- Unit industrial wastewater generation is to be 80 % of water consumption.
- Average BOD_5 concentration in industrial wastewater is to be 425 mg/l.
- Characteristics of river and canal such as flow, self purification and dilution capacity and effect of tidal influence are same in the future as present.
- Simple mathematical equation is used with the assumption of that relationship between water quality of rivers and canals and pollution load discharged is same in the future as that of now.

The evaluation result is shown in the table below.

Evaluation of Future Water Quality of Rivers/Canals for Each Case

River/Canal	BOD$_5$ (mg/l)			
	Present (1997)	Case I (2020)	Case II (2020)	CaseIII(2020)
Saigon River at Tan Tuan reach	50~210	95~400	88~370	5 – 7
Tau Hu at Y Bridge	80~250	130~400	125~395	10 – 15
Tan Hoa-Lo Gom at Tan Hoa street	330~540	460~760	460~760	10 – 20
Nhieu Loc-Thi Nghe at Ly Bridge	120~210	200~360	200~360	10 – 15
Tham Luong-Vam Thuat at Ben Pham Bridge	35~140	90~360	80~320	10 – 20

Remark : Industrial wastewater generation is calculated by land use from UPI.

Although the figures of BOD$_5$ concentration in the above table are the result by simplified calculation, ignoring the effect of sediment deposit and change in hydraulic characteristics of rivers/canals, the result will suggest the following things.

(1) Domestic wastewater seems to be the major organic pollution source, therefore, industrial wastewater treatment alone to the level of the discharge standard will not reduce organic pollution of water bodies such as rivers and canals.

(2) By simultaneous wastewater treatment of domestic wastewater by sewerage and on-site sanitation improvement system and industrial wastewater treatment with 90% of BOD$_5$ removal rate will considerably improve water quality of water bodies such as rivers and canals.

Added to this, another overall measures to improve water quality of rivers/canals to lower level should be recommended as follows.

- Solid waste management including enforcement by the law.
- Dredging the sediment deposit accumulated on the bottom of rivers/canals.
- Measures for reducing pollutants from houses and industrial estates such as oil, garbage, heavy metals, other hazardous compounds and so on to water bodies and treatment facilities.

II. Feasibility Study

10. Planning Conditions

10.1 Target Year

The sewerage development for the priority project is proposed with the target year of 2010.

10.2 Sewerage Service Area

(1) General

The Project Area of sewerage development covers an area of 3,065.4 ha, which consist of following nine (9) districts located in the central area of Ho Chi Minh City. The project area is shown in Fig. F.10.1.

District	Sewerage Service Area (ha)
1	607.8
3	51.2
4	416.5
5	429.2
6	163.2
8	808.1
10	289.3
11	181.7
Tan Binh	118.4
Total	3,065.4

Tau Hu – Ben Nghe canal and Doi – Te canal run from west to east in the Project Area. And Saigon River flows the east boundary of the Project area. These water ways and the areas of zoo, national stadium, etc. of 273.8 ha are not included in the sewerage service area. The details of exclusive area from the sewerage service area are as follows.

Saigon river : 59.6 ha, Tau Hu – Ben Nghe canal : 46.5 ha, Doi – Te canal : 66.8 ha, Other canals : 15.7 ha, Zoo : 20.6 ha, Thong Nhat Palace : 12.6 ha, Tao Dan Park : 19.7 ha, Phu Tho Stadium : 32.3 ha

Hence, the sewerage service area covers 2,791.6 ha with a total population of 1,421,778 in 2010 and 1,309,282 in 2020 respectively.

11. Interceptor Sewer

11.1 Introduction

Collection of wastewater in Tau Hu, Ben Nghe – Doi, Te (THBNDT) zone is proposed to utilize the existing combined sewer system as much as possible from the economical view point. Then the interceptor sewer is required to collect the dry weather flow from the existing combined sewer system. This section aims to select an optimum interceptor system for THBNDT zone from the technical and economical points of view.

11.2 Division of Sewerage Area

The sewerage area of 2,791.6 ha is separated by Tau Hu – Ben Nghe and Doi Te canals into three (3) areas; 1) left bank area of Tau Hu - Ben Nghe canal, 2)isolated area by Tau Hu - Ben Nghe and Doi Te canal, and 3) right bank area of Doi – Te canal. And these three (3) separated sewerage areas are further divided into 24 sub-zones as shown in Fig. F.11.1 and listed in table below. The division is made based on existing combined sewer networks, canals, rivers, main roads and topography.

Sub-zone	Area (ha)	Covered District
(1) Tau Hu – Ben Nghe Canal Left Bank		
1. Sub-zone 1	132.4	1
2. Sub-zone 2	141.2	1, 3
3. Sub-zone 3	22.0	1
4. Sub-zone 4	72.9	1
5. Sub-zone 5	71.8	1, 3
6. Sub-zone 6	47.0	1
7. Sub-zone 7	232.1	1, 3, 5, 10
8. Sub-zone 8	44.9	1, 5
9. Sub-zone 9	40.4	5, 10
10. Sub-zone 10	23.7	5
11. Sub-zone 11	78.5	5, 10
12. Sub-zone 12	15.2	5
13. Sub-zone 13	277.1	5, 10, 11
14. Sub-zone 14	214.5	5, 6, 10, 11, Tan Binh
15. Sub-zone 15	168.6	5, 6, 11, Tan Binh
16. Sub-zone 16	111.1	6
Sub Total	1,693.4	
(2) Islands between Tau Hu – Ben Nghe and Doi – Te Canals		
17. Khanh Hoi	350.2	4
18. Ong Kieu	3.9	4
19. Hung Phu	76.7	8
20. Tung Thien Vuong	82.0	8
21. Binh Dong	48.6	8
Sub Total	561.4	
(3) Doi – Te Canal Right Bank		
22. Rach Ong	133.0	8
23. Pham The Hien	195.8	8
24. Binh Dang	208.0	8
Sub Total	536.8	
Total	2,791.6	

Note : The following areas are excluded from the sewerage service area. The excluded area is estimated at 273.4 ha.

(1) Zoo = 20.6 ha in sub-zone 1
(2) Thong Nhat Palace = 12.6 ha in sub-zone 2
(3) Tao Dan Park = 19.7 ha in sub-zone 2
(4) Phu Tho Stadium = 24.4 ha in sub-zone 12 and 7.9 ha in sub-zone 13
(5) Saigon River = 59.5 ha, Tau Hu – Ben Nghe Canal = 46.5 ha, Doi – Te Canal = 66.8 ha, Other Rivers/Canals = 15.4 ha

The population by sub-zones in 1997, 2010 and 2020 are estimated as followings.

Sub-zone	1997		2010		2020	
	Covered Population	Population Density (person/ha)	Covered Population	Population Density (person/ha)	Covered Population	Population Density (person/ha)
(1) Tan Hu – Ben Nghe Canal Left Bank						
1. Sub-zone 1	19,933	151	19,871	150	19,823	150
2. Sub-zone 2	44,971	318	44,688	316	44,470	315
3. Sub-zone 3	12,543	570	12,428	565	12,340	561
4. Sub-zone 4	51,513	707	48,331	663	46,034	631
5. Sub-zone 5	32,333	450	32,041	446	31,820	443
6. Sub-zone 6	38,341	816	36,044	767	34,374	731
7. Sub-zone 7	163,247	703	159,187	686	156,189	673
8. Sub-zone 8	31,366	699	28,425	633	26,355	587
9. Sub-zone 9	25,949	642	25,038	620	24,363	603
10. Sub-zone 10	21,874	923	19,777	834	18,303	772
11. Sub-zone 11	62,892	801	61,771	787	60,936	776
12. Sub-zone 12	10,679	703	9,310	613	8,377	551
13. Sub-zone 13	153,275	553	147,211	531	142,958	516
14. Sub-zone 14	132,401	617	129,482	604	126,901	592
15. Sub-zone 14	88,578	525	89,250	529	89,308	530
16. Sub-zone 14	69,864	629	68,795	619	68,083	613
Sub total	959,759	567	931,649	550	910,634	538
(2) Islands between Tan Hu – Ben Nghe and Doi – Te Canals						
17. Khanh Hoi	219,217	626	213,228	609	209,134	597
18. Ong Kieu	1,434	372	1,077	279	864	224
19. Hung Phu	67,220	876	59,739	779	54,806	714
20. Tung Thien Vuong	51,588	629	44,295	540	40,847	498
21. Binh Dong	21,369	440	19,952	411	18,926	390
Sub total	360,828	643	338,291	603	324,577	578
(3) Doi – Te Canal Right Bank						
22. Rach Ong	68,615	523	67,480	515	66,778	509
23. Pham The Hien	40,361	219	42,796	232	44,768	243
24. Binh Dang	39,140	202	41,562	215	43,525	225
Sub total	148,116	288	151,838	295	155,071	302
Total	1,468,703	526	1,421,778	509	1,390,282	498

11.3 Design Wastewater Discharge

In the Project Area, the considerable portion of the toilet waste is treated by the individual septic tank. However, the sufficient treatment efficiency of the septic tank is not expected because of their insufficient maintenance. Hence, the treatment efficiency of the septic tank is ignored to determine the domestic wastewater quality and quantity. The wastewater discharge is defined as wastewater consisting both toilet waste and gray water.

Wet weather discharge of 1.4 times of dry weather discharge is applied for designing interceptor and conveyance sewer. Size of interceptor and conveyance sewer is Sdesigned to meet the possible maximum wastewater discharge since flow capacity of interceptor and conveyance sewers cannot be enlarged in stage easily. Hence, design wastewater discharge of interceptor and conveyance sewers is determined to be wet weather discharge in 2020 plus groundwater infiltration of 10% of dry weather daily average wastewater discharge in 2000.

Design wastewater discharge consisting of wet weather discharge and groundwater infiltration in each sub-zone is estimated as below.

Sub-zone	Design Wastewater Discharge (m^3/day) (2020)		
	Wastewater	Groundwater	Total
(1) Tau Hu – Ben Nghe Canal Left Bank			
1. Sub-zone 1	9,297	664	9,961
2. Sub-zone 2	20,856	1,490	22,346
3. Sub-zone 3	5,788	413	6,201
4. Sub-zone 4	21,589	1,542	23,131
5. Sub-zone 5	14,924	1,066	15,990
6. Sub-zone 6	16,121	1,152	17,273
7. Sub-zone 7	73,252	5,232	78,484
8. Sub-zone 8	12,361	883	13,244
9. Sub-zone 9	11,427	816	12,243
10. Sub-zone 10	8,585	613	9,198
11. Sub-zone 11	28,580	2,041	30,621
12. Sub-zone 12	3,928	281	4,209
13. Sub-zone 13	67,047	4,789	71,836
14. Sub-zone 14	59,517	4,251	63,768
15. Sub-zone 15	41,885	2,992	44,877
16. Sub-zone 16	31,931	2,281	34,212
Sub Total	427,088	30,506	457,594
(2) Islands between Tau Hu – Ben Nghe and Doi – Te Canals			
17. Khanh Hoi	98,084	7,006	105,090
18. Ong Kieu	405	29	434
19. Hung Phu	25,704	1,836	27,540
20. Tung Thien Vuong	19,158	1,368	20,526
21. Binh Dong	8,876	634	9,510
Sub Total	152,227	10,873	163,100
(3) Doi – Te Canal Right Bank			
22. Rach Ong	31,319	2,237	33,556
23. Pham The Hien	20,996	1,500	22,496
24. Binh Dang	20,413	1,458	21,871
Sub Total	72,728	5,195	77,923
Total	652,043	46,574	698,617

11.4 Outline of Each Sewerage Sub-Zone

As stated above, THBNDT zone is separated into three (3) sewerage areas. The existing land use condition of three (3) sewerage areas are as follows.

(1) Left Bank Area of Tau Hu – Ben Nghe Canal :

The area has been developed as the central area of Ho Chi Minh City since French colonial era. Combined sewer system was also installed along the roads. In the east area covering District 1, 3 and 5 is fully developed with an adequate road networks, some potential roads can be installed interceptor sewer are along and parallel to the canals. While in west area consisting of District 6,10 and 11 is very congested area and China Town called "Cho Lon" is located along Tau Hu canal. In this west area, only Tran Van Kieu road along Tau Hu canal is recognised as the potential route of the interceptor sewer.

(2) Isolated Area by Tau Hu – Ben Nghe and Doi – Te Canals :

In this area, roads are existed along both canals of Tau Hu – Ben Nghe and Doi – Te. There are no alternative routes for installation of the interceptor sewer except along the canals.

(3) Right Bank Area of Doi – Te Canal :

This area is not fully developed yet. Road networks are not sufficient to develop the sewer system. This area will be developed near soon. The sewerage system will be also developed harmonized with the land development. The Vietnamese standards stipulates that the sewerage development for newly developed area must be covered by separate sewer system. Hence the separate sewer system is proposed in this right bank area of Doi – Te canal.

11.5 Alternative Study of Interceptor Route for East Area of Left Bank of Tau Hu – Ben Nghe Canal

There are two (2) alternative routes for the interceptor sewer; one is Ton Duc Thang – Ham Nghi – Tran Hung Doa roads and second one is Ton Duc Thang – Ben Chuong Duong roads. Based on these two (2) alternative routes, following three (3) options of the interceptor sewer are considered as shown in Fig. F.11.2

11.5.1 Alternative Plan A

Route : Main Interceptor ⇒ along Ton Duc Thang – Ham Nghi – Tran Hung Dao streets
Secondary Interceptor ⇒ along Ben Chuong Duong Street

Two (2) lines of interceptor sewer are proposed. The main interceptor sewer is installed along Ton Duc Thang – Ham Nghi – Tran Hung Dao streets to collect the wastewater from the sub-zones of No.1, 2, 3, 5, 7 and 9. The secondary interceptor is planed along Ben Chuong Duong Street to collect the wastewater from the sub-zones of No.4, 6, 8 and 10.

The calculation sheet of interceptor sewer is presented in Table F.11.1. The main features of the interceptor sewer are shown as follows.

Length	:	Total	:	9,710 m
		Main	:	5,480 m
		Secondary	:	4,230 m
Interceptor Diameter	:	Main	:	φ 700 mm ~ φ 1,500 mm
	:	Secondary	:	φ 600 mm ~ φ 800 mm
Earth Covering Depth	:	Main	:	3.7 ~ 10.4 m
		Secondary	:	1.2 ~ 8.3 m
Construction Method	:	Open Cut Method	:	7,070 m
		Pipe Jacking Method	:	2,640 m

Construction cost of **Alternative Plan A** is estimated at 166 billion VND. The break down is shown in Table F.11.1.

11.5.2 Alternative Plan B

Route : Main Interceptor ⇒ along Ton Duc Thang – Ben Chuong Duong streets

The interceptor sewer is proposed under Ton Duc Thang – Ben Chuong Duong streets located along Saigon river and Tau Hu – Ben Nghe canal. Diversion chambers to collect the dry weather flow from the sub-zones of No.1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 are placed at each outlet of the existing combined sewer before discharging the Saigon river and Tau Hu – Ben Nghe canal.

The calculation sheet of interceptor sewer is presented in Table F.11.2. The main features of the interceptor sewer are shown as follows..

Length	:	Main	:	5,405 m

Interceptor Diameter	:	Main	:	ϕ 700 mm ~ ϕ 1,500 mm
Earth Covering Depth	:	Main	:	3.7 ~ 10.3 m
Construction Method	:	Open Cut Method	:	2,525 m
		Pipe Jacking Method	:	2,880 m

Construction cost of **Alternative Plan B** is estimated at 168 billion VND. The break down is shown in Table F.11.2.

11.5.3 Alternative Plan C

Route	:	Main Interceptor	⇒	along Ton Duc Thang – Ham Nghi – Tran Hung Dao streets
Route	:	Secondary Interceptor	⇒	under the streets perpendicular to Ben Chuong Duong Street

The main interceptor is planed along Ton Duc Thang – Ham Nghi – Tran Hung Dao streets to collect the wastewater from the sub-zones of No. 1, 2, 3, 5, 7 and 9 as same as Alternative Plan A.

For collection of wastewater from sub-zones of 4, 6, 8 and 10, the secondary interceptor sewer is proposed along the roads, which are perpendicular to Ben Chuong Duong street and conveys it to the main interceptor along Ton Duc Thang – Ham Nghi – Tran Hung Doa street.

The calculation sheet of interceptor sewer is presented in Table F.11.3. The main features of the interceptors are shown as follows.

Length	:	Main		5,480 m
Interceptor Diameter	:	Main	:	ϕ 700 mm ~ ϕ 1,500 mm
Earth Covering Depth	:	Main	:	3.7 ~ 10.3 m
Construction Method	:	Open Cut Method	:	2,640 m
		Pipe Jacking Method	:	2,840 m

Construction cost of **Alternative Plan C** is estimated at 168 billion VMD. The break down is shown in Table F.11.3.

11.5.4 Proposed Plan

From the economical point of view, there is no significant difference among three alternative plans.

Basically, interceptor sewer is installed along rivers and canals to intercept the wastewater before it discharges to those water bodies. From this concept, **Alternative Plan B** is the most appropriate one. While the Ben Chuong Duong street along Ben Nghe canal has a plan to connect Thu Thiem area crossing Saigon River by tunnel. Access road of about 1,000 m to Saigon river crossing tunnel is required to construct under the Ben Chuong Duong street. This access road, which will be constructed by the diaphragm wall much affects the existing drainage system along the Ben Chuong Duong street. The existing drainage sewers to Ben Nghe canal will be affected by the diaphragm wall and required to construct by-pass sewer to Saigon river or up stream of Ben Nghe canal. Hence, **Alternative Plan C** is proposed as the optimum interceptor route to avoid the congestion of drainage and interceptor sewers under the Ben Chuong Duong street.

11.6 Collection System for Other Sewerage Development Area

11.6.1 West Area of Left Bank of Tau Hu –Ben Nghe Canal

According to the final report on " Ho Chi Minh City Environmental Improvement Project " prepared by ADB, drainage condition of Hang Bang area will be improved by newly installed north-south direction combined sewers those are planed to directly discharge the wastewater into the Tau Hu canal. Thus the wastewater shall be collected immediately before discharging to Tau Hu canal. The interceptor sewer shall be installed under Tran Van Kieu and Ben Ham Tu roads when these will be expanded. The interceptor sewer route is shown in Fig. F.11.1.

The calculation sheet of interceptor sewer is presented in Table F.11.3. The main features of the interceptors are shown as follows.

Main Features

Total Length	:	4,990 m		
Interceptor Diameter	:	ϕ 700 mm ~ ϕ 1,500 mm		
Earth Covering Depth	:	1.2 ~ 7.4 m		
Construction Method	:	Open Cut Method	:	4,240 m
		Pipe Jacking Method	:	750 m

Construction cost is estimated at 60.0 billion VND. The break down is shown in Table F.11.3.

11.6.2 Khanh Hoi Sub-zone

Two (2) lines of interceptor sewer are proposed under Ben Van Don and Ton That Thuyet roads running along the Ben Nghe and Te canals, respectively. The interceptor sewer along the Ben Van Don road joins the other one running along Tong That Thuyet road and the merged interceptor sewer finally joins the main sewer installed in Rach

Ong sub-zone after crossing Te canal. The route and the longitudinal profile of the interceptor sewer are shown in Fig. F.11.3, F.11.4 and F.11.5 , respectively.

Main Features

Total Length	:	6,513 m (include canal crossing)		
Interceptor Diameter	:	ϕ 450 mm ~ ϕ 1,200 mm		
Earth Covering Depth	:	1.2 ~ 5.45 m		
Construction Method	:	Open Cut Method		
Canal Crossing	:	Canal Name	:	Te Canal
		Length	:	179 m
		Construction Method	:	Shield Tunneling
		System	:	Siphon with ϕ 900 mm x 2 lines

The construction cost is estimated at 38 billion VND and the breakdown is shown in Table F.11.4.

11.6.3 Hung Phu Sub-zone

Two (2) lines of interceptor sewer are proposed under the Ben Ba Dinh and Ben Nguyen Duy roads on both sides of sub-zone along the canals. After joining both interceptor sewers, the merged interceptor sewer crosses the Doi canal at the intersection of Chanh Hung and Ben Nguyen Duy roads and connects to the main sewer installed in Pham The Hien sub-zone. The route and the longitudinal profile of the interceptor sewer are shown in Fig. F.11.3 , F.11.6 and F.11.7, respectively.

Main Features

Total Length	:	4,543 m (include canal crossing)		
Interceptor Diameter	:	ϕ 400 mm ~ ϕ 500 mm		
Earth Covering Depth	:	1.2 ~ 4.35 m		
Construction Method	:	Open Cut Method		
Canal Crossing	:	Canal Name	:	Doi Canal
		Length	:	160 m
		Construction Method	:	Pipe Jacking Method
		System	:	Siphon with ϕ 600 mm x 2 lines

The construction cost is estimated at 14 billion VND and the breakdown is shown in Table F.11.4.

11.6.4 Tung Thien Vuong Sub-zone

Two (2) lines of interceptor sewer are proposed under the Ben Binh Dong and Ben Nguyen Duy roads on both sides of sub-zone along the canals. After joining both interceptor sewers, the merged interceptor sewer crosses Doi canal beside the Nhi Thien Duong bridge and reaches to the main sewer installed in Binh Dang sub-zone. The route and the longitudinal profile of the interceptor sewer are shown in Fig. F.11.3, F.11.8 and F.11.9, respectively.

Main Features

Total Length	:	4,870 m (include canal crossing)		
Interceptor Diameter	:	ϕ 400 mm ~ ϕ 700 mm		
Earth Covering Depth	:	1.2 ~ 5.01 m		
Construction Method	:	Open Cut Method		
Canal Crossing	:	Canal Name	:	Doi Canal
		Length	:	150 m
		Construction Method	:	Pipe Jacking Method
		System	:	Siphon with ϕ 500 mm x 2 lines

The construction cost is estimated at 17 billion VND and the breakdown is shown in Table F.11.4.

11.6.5 Binh Dong Sub-Zone

Interceptor sewers are proposed under roads surrounding Binh Dong sub-zone. Collected wastewater by the interceptor sewers is transferred to the main sewer in Tung Thien Vuong sub-zone. Crossing under Ngang No.1 canal by pipe jacking method is proposed near by the bridge. The route and the longitudinal profile of the interceptor sewer are shown in Fig. F.11.3 and Fig. F.11.8, respectively.

Main Features

Total Length	:	2,543 m (include canal crossing)		
Interceptor Diameter	:	ϕ 400 mm ~ ϕ 450 mm		
Earth Covering Depth	:	1.2 m ~ 4.23 m		
Construction Method	:	Open Cut Method		
Canal Crossing	:	Canal Name	:	Ngang 1 Canal
		Length	:	42 m
		Construction Method	:	Open Cut Method
		System	:	Siphon with ϕ 350 mm x 2 lines

The construction cost is estimated at 3 billion VND and the breakdown is shown in Table F.11.4

11.6.6 Rach Ong, Pham The Hien and Binh Dang Sub-zones

The right bank area of Doi – Te canal is proposed to be developed by separate sewer system as mention above. Hence secondary/tertiary and main sanitary sewers will be installed in this area. The area consists of 3 sub-zones, which are Rach Ong, Pham The Hien and Binh Dang areas and the total amounts to 537 ha (refer to Fig, F.11.1).

The interceptors planned for the area isolated by Tau Hu – Ben Nghe and Doi – Te Canal are proposed to be installed along the roads in the 3 sub-zones. Consequently, the main sanitary sewers for these sub-zones will be connected to the interceptor running along the canal.

The total length of the secondary/tertiary and the main sanitary sewers are 26 km and 35 km, respectively. The pipe diameter ranges from ϕ 300 mm to ϕ 600 mm and the main features of the new drainage pipe by each sub-zone are presented in the table below.

Sewer	Diameter (mm)	Rach Ong (133 ha)	Pham The Hien (196 ha)	Binh Dang (208 ha)	Total
Secondary /Tertiary	300	6,384	9,398	9,984	25,766
Main	300	7,161	18,747	5,289	31,197
	400	782	287	920	1,989
	500	995	-	647	1,642
	600	-	-	250	250
Total		15,322	28,432	17,090	60,844
No. of House Connection		67,480	42,796	41,562	151,838
No. of Manhole		279	388	391	1,058

12. Diversion Chamber

12.1 Introduction

To intercept wastewater from the existing combined sewers, diversion chamber is installed nearby their outlets. All existing combined sewers are affected by tide of their down stream near the outlet. Hence designing diversion chamber, high water level of the receiving water bodies should be taken into consideration. Diversion chamber is installed under the existing road or sidewalk with a flap gate to avoid the affection of high tide.

103 units of outlet of combined sewer exist in the priority project area. The location is shown in Fig. F.12.1 and their detailed are described in Table F.12.1.

12.2 Design Condition

The proposed typical diversion chamber is shown in Fig. F.12.2. The orifice is designed to divert the wastewater to the interceptor sewer. The weir with a flap gate is installed at the center of the diversion chamber. From the maintenance reason, typical plane internal dimension of 2m x 2.2m is proposed.

Based on the sewage flow conditions in the combined sewer and water level conditions of receiving water bodies, following four (4) cases should be taken into consideration to divert the design wastewater to the interceptor sewer.

Case	Flow Condition	Water level of Down Stream
A	Dry weather flow	Low tide
B	Wet weather flow	Low tide
C	Dry weather flow	High tide
D	Wet weather flow	High tide

Hydraulic condition of diversion chamber under the different four (4) cases mentioned above are explained in Fig. F.12.3 and Fig. F.12.4.

1.4 times daily average wastewater discharge and groundwater infiltration is proposed as the design diversion water volume.

Design highest water level of receiving water bodies is applied at +1.4 m above mean sea level at Mui Nai.

12.3 Preliminary Design

Case A mentioned above is the basic condition to determine the dimension and vertical location of orifice to divert the design water volume. In Case C, weir with flap gate avoids the affection of down stream water level to diversion orifice. Hence all dry weather flow is diverted as same condition as Case A.

While in Case B, storm water along with wastewater is discharged in the combined sewer. Then water level in the combined sewer becomes higher than that of dry weather flow even in low tide. This higher water level causes to divert the excessive water ranging from 32% to 44% more than the design diversion water volume. Furthermore in Case D, up stream water level becomes higher than design down stream high water level of +1.4 m to discharge the excess water through flap gate to rivers and canals. Simultaneously, diverted water volume becomes 2 times larger than the design diverted water volume. This phenomenon affects the design capacities of interceptor sewer and intermediate pumping station.

Depend on the design diversion water volume, two (2) sizes of square type orifice are applied to minimize the excessive water diversion in wet weather flow. Orifice of the dimension of 10 cm x 10 cm is applied for design diversion water volume of less than 0.10 m^3/sec and the dimension of 30 cm x 30 cm is applied for more.

Orifice of 10cm x 10cm diverts water about 32% and 64% much more than the design diverted water volume in Case B and Case D respectively. These excessive diversion water volume are not expected to affect the capacities of interceptor sewer and intermediate pumping station because of their relatively small volume. While orifice of 30cm x 30cm diverts water about 44% and 2 times more than the design diverted water volume in Case B and Case D. These excessive diversion water much affects the design of interceptor sewer and intermediate pumping station. To reduce the excessive water diverted to interceptor sewer, stop log is equipped at the orifice. In rainy season, orifice size will be reduced 50 % by stop log. And excessive diversion water can be reduced to same as the design diversion water volume.

13. Conveyance Sewer

13.1 Alternative Study of Conveyance Sewer Route

The conveyance route was proposed in Interim Report based on the existing topographic map and a preliminary field survey. However, the conveyance sewer with a length of about 3 km runs across paddy field in a poor soil condition.

Consequently, prior to the installation of conveyance sewer, a new road shall be constructed in the paddy filed and land acquisition for the new road is also required. For those reasons, the construction cost of conveyance sewer running across the paddy field is estimaSted higher than that of under an existing road.

This study aims to seek the optimum conveyance sewer route from technical and economical points of view. The study takes the following 3 factors into account.

- Location of intermediate pumping station
- Canal crossing route
- Conveyance route

Selection Criteria

- Existing combined sewer network
- Existing main road
- Impact to traffic on a road and neighborhood's living from a economical point of view
- Obstructions, such as water supply pipe and so on
- Possibility of immediate implementation
- Workability of construction
- Construction method and cost

13.2 Options of Conveyance Sewer Route

3 options of conveyance sewer route are selected based on the selection criteria stated above. The outline of 3 options is shown in Fig. F.13.1 and the table below.

Route		
(A) Nguyen Bieu	(B) Tran Tuan Khai	(C) Nguyen Tri Phuong
1. Nearer to downtown area which is considered to be implemented at 1st phase 2. 1 place of canal crossing 3. Available open space (Da Nam park) for PS	1. Larger available open space for PS 2. Shortest length of canal crossing	1. Available open space for PS facing to existing main road 2. Tennis court belonging to district office to be utilized as work yard for construction

For 3 options presented above, a comparison table was prepared to evaluate these options based on the selection criteria. The detail is shown in Table F.13.1.

According to the table, Route (B) is given the highest score. The comparison results that Route (B) is the optimum one from technical points of view.

13.3 Construction Cost

To estimate the construction costs for 3 options of the conveyance sewer, the following conditions are considered.

1) Pipe Jacking Method and Shield Tunneling Method are applied to the construction of conveyance sewer with an earth covering depth of deeper than 6 m and river crossing, respectively.
2) Trench Method is applied to the construction of conveyance sewer installed with an earth covering depth of shallower than 6 m.
3) A new road is constructed along the conveyance sewer route running across paddy field.

The construction costs for 3 options are estimated as follows.

Description		Route					
		(A) Nguyen Bieu		(B) Tran Tuan Khai		(C) Nguyen Tri Phuong	
		Length (m)	Construction Cost (Billion VND)	Length (m)	Construction Cost (Million VND)	Length (m)	Construction Cost (Million VND)
Canal Crossing	Pipe Jacking	500	28,000	500	28,000	650	36,400
	Shield Tunnel	300	26,700	500	44,500	650	57,850
	Total	800	54,700	1,000	72,500	1,300	94,250
Conveyance		6,450	191,702	5,400	135,220	5,550	135,209
Sub-Total			246,402		207,720		229,459
Pumping Station	Civil Work		128,686		86,521		86,141
	E/M Work		54,952		54,952		54,952
	Sub-Total		183,638		141,473		141,093
Total			430,040		349,193		370,552

The comparison table results that Route (B) and Route (A) are the lowest cost and the highest cost options, respectively.

The construction cost of conveyance sewer for Route (B) is slightly higher than Route (C) owing to construction of new road with a longer length. In addition, the pumping station for Route (B) costs slightly higher than Route (C) because of site preparation.

The conveyance sewer of Route (A) is the longest one of 2.6 km long with an earth covering depth deeper than 6 m. That is the reason the construction cost is estimated higher than other 2 options. As for the pumping station of Route (A), the cost includes the restoration work of the park as it used to be. That also make the cost of Route (A) higher than other 2 options.

13.4 Comparison between Gravity and Pressured Pipe Conveyance Systems

The conveyance sewer runs across paddy field with a length of approximately 3 km with an earth covering depth of deeper than 6 m. For the installation of conveyance sewer in the deeper layer, additional works of retaining and dewatering shall be required.

To reduce the construction cost, Pressured Pipe System is considered as an alternative of conveyance sewer. Advantages of Pressured Pipe Conveyance System are listed as follows;

- Installation with a shallower earth covering of about 1 m, that is required to avoid a damage from traffic load.
- Bending in the vertical alignment are allowed.
- Conveyance sewer crosses rivers by bridge.
- Maintenance works of the section of river crossing are easier than Gravity Conveyance.

- Inflow pumping station for Wastewater Treatment Plant is not necessary.

However, the following disadvantages are also expected.

- Additional pipe with the same diameter running parallel to the conveyance sewer is necessary for maintenance and emergency.
- Sediments are liable to accumulate in the pipe due to intermitted operation.
- Frequent maintenance works such as cleaning is necessary to remove sediments.
- No experience of a sewage pressured pipe system with such a large diameter in Japan.

[Construction Cost]

The comparison table of the construction costs is shown below.

Description	Construction Cost			
	Gravity System		Pressured Pipe System	
	Length (m)	Construction Cost (Million VND)	Length (m)	Construction Cost (Million VND)
Canal Crossing	1,000	72,500	1,000	72,500
Conveyance	5,400	135,220	5,400	206,391
Sub-Total		207,720		278,891
Intermediate Pumping Station	Civil Work	86,521	Civil Work	86,521
	E/M Work	54,952	E/M Work	82,428
	Sub-Total	141,473	Sub-Total	168,949
Inflow Pumping Station at WTP	Civil Work	51,913	Civil Work	-
	E/M Work	46,709	E/M Work	-
	Sub-Total	98,622	Sub-Total	-
Total Construction Cost		447,815		447,840

The construction costs of Gravity System includes the inflow pumping station at the wastewater treatment plant. According to the estimation, total construction costs of both systems are about the same amount.

The construction cost of conveyance sewer of the pressured pipe system is approximately 1.34 times higher than that of the gravity system. A suitable pipe for the pressured pipe system such as a cast iron pipe is not available in Viet Nam, therefore imported pipe is used for the pipe line.

However, the gravity system requires 2 pumping stations, therefore the cost of pumping station for the gravity system is estimated 1.42 times higher than that of the pressured pipe system.

[Operation and Maintenance Cost]

Annual operation and maintenance costs for those system are also estimated as follows.

Description	Annual O/M Cost			
	Gravity System		Pressured Pipe System	
	Quantity	Annual O/M Cost (Million VND)	Quantity	Annual O/M Cost (Million VND)
Electrical Power for Pumping Station	2,900 kwh	17,782	2,500 kwh	15,330
Pumping Station	-	720	-	507
Pipe Cleaning	Once a year for 1 line	406	Once 2 months for 1 line	3,715
Total O/M Cost		18,908		19,552

Note : Electrical Charge of 700 VND/kw is applied.

Annual expenditure on electric for the gravity system is approximately 2.5 billion VND higher than the pressured pipe system because 2 pumping station are necessary for the gravity system.

However, periodical cleaning of the pressured pipe must be required to prevent sediments that generate hydrogen sulfide gas (H_2S) from anaerobic decomposition because H_2S causes corrosion of pipe. Expenditure on pipe cleaning is estimated on condition frequency of cleaning is once a year for the gravity pipe line and once a month for the pressured pipe line.

As a result, the annual O/M cost for the pressured pipe system is approximately 0.6 billion higher than the gravity system.

13.5 Proposed Plan

There is no significant difference between the two systems, however annual O/M cost for the gravity pipe system is lower than the pressured pipe system.

Furthermore, the gravity system has an advantage of high reliability operation over the pressured pipe system.

Finally, the gravity system is recommended as the optimum system for conveyance sewer.

Proposed alignment and longitudinal profile of conveyance sewer are shown in Fig. F.13.2 and Fig. F.13.3, respectively. The main features of proposed conveyance sewer are shown below:

Main Features

Total Length	: 5,400 m (include canal crossing)
Interceptor Diameter	: ϕ 2,000 mm ~ ϕ 2,500 mm
Earth Covering Depth	: 1.2 ~ 8.6 m
Construction Method	: Open Cut Method (3,850 m) Shield Tunneling Method (1,500 m) Pipe Jacking (50m)
River/Canal Crossing (1)	: Canal Name : unknown Length : 50 m Construction Method : Pipe Jacking System : Gravity with ϕ 2,500 mm x 1 lines
(2)	: River Name : Ong Be Length : 100 m Construction Method : Shield Tunneling System : Gravity with ϕ 2,500 mm x 1 lines

14. Intermediate Sewage Pumping Station

A total length of the interceptor and conveyance sewers amount to approximately 11 km. If no intermediate sewage pumping station were installed, the depth of the conveyance at the wastewater treatment plant would be estimated at deeper than G.L.- 20 m. The Hence an intermediate sewage pumping station is required to install sewer pipe at an appropriate depth because of the following reasons.

1) Optimize the construction cost
2) Apply a conventional construction method
3) Assure a easiness of maintenance of sewer and pumping station

14.1 Site Selection

The pumping station should be located after crossing the Doi Canal because the bottom elevation of the Doi Canal is measured approximately 8 m deep from the mean sea level at Mui Nai. Consequently, some potential sits for the pumping station were found as mentioned in the section of the alternative study on the conveyance route.

Finally, the location of the proposed intermediate sewage pumping station site was determined in Ward 3 in District 8 (Refer to Fig. F.14.1).

14.2 Site Condition

An average of the existing land elevation of this area is approximately G.L. + 1.4 m above mean sea level at Mui Nai and the area is swamp area.

The area is expected to be covered by Holocene, Pleistocene and Pliocene deposits at the top layer with a thickness of 0.5 m. Based on the soil investigation conducted by JICA Study Team, the base layer of the soil is not found until a depth of 8.5 meters from the ground surface. The characteristics of both alluvial and diluvial layers are described below.

Layer	Depth (m)	Nature of soil	SPT (N value)
1	0~ 0.9	Clayey Sand	-
2	3 ~5	Organic Clay	0 ~ 1
3	5 ~ 6.5	Clay	3
3a	6.5 ~ 8	Clayey Sand	0 ~ 3
4	8 ~ 8.5	Clayey Sand	11 ~ 20
4a	8.5 ~ 12	Silty, Clayey Sand	12 ~ 24
4b	12 ~ 39	Sand with Silt	18 ~ 21
5	39 ~ 50	Clay	36 ~ 46

14.3 Design Condition

14.3.1 Design Flow

Daily average wastewater discharge in dry weather flow including groundwater infiltration (10% of daily average discharge) in the year 2010 is applied for design of the intermediate sewage pumping station. The design flow of 469,000 m^3/day consisting wastewater of 426,500 m^3/day and groundwater of 42,500 m^3/day is applied as dry weather flow. The wet weather flow of 1.4 times of dry weather discharge plus groundwater infiltration is used as an hourly maximum discharge for design capacity of the pumping station and is computed to be 640,000 m^3/day.

14.3.2 Main Facilities

The intermediate pumping station consists of the following facilities;

1) Inlet Gate & Channel
2) Pump Well
3) Pump Pit
4) Pump
5) Coarse Screen
6) Grit Chamber
7) Fine Screen
8) Outlet Gate & Channel

The invert level of the inlet pipe connected to the conveyance with a diameter of 2,000 mm is estimated at G.L. - 12.6 m. The invert level of the outlet pipe connected to the conveyance with a diameter of 2,500 mm is estimated at G.L. -- 4.0 m.

14.4 Alternative Study of Intermediate Sewage Pumping Station

In general, Grit Chamber is installed before pumps to remove grit and to remove solids that might clog pumps. However, the invert elevation of the interceptor connecting to the intermediate pumping station for THBNDT sewerage zone reaches approximately G.L.-13 m. Consequently, the grit chamber according to an idea of conventional alignment is installed at a depth of G.L.-15 m .

However, there are several types pumps which can deal with a lager solids and the grit chamber has been installed after pumps in some pumping stations. Because the construction of the grit chamber contribute to reduce the volume of civil work and the construction cost.

Consequently, two (2) options of alignment of the grit chamber are examined to determine an optimum one in this study.

Comparison between Forward Grid Chamber and Backward Grid Chamber for Pumping Station

Option A Backward Grid Chamber (see Fig. F.14.2)	Option B Forward Grid Chamber (see Fig. F.14.3)
Advantage	
(Structure Design) 1. Depth of Grit Chamber is about 10 m shallower. 2. Length of Grit Chamber is about 8 m shorter. 3. Height of Bar Screen is Smaller. 4. Size of devices for scraper and chain-driven rake to clean the channel and screen reduced and gate. 5. Volume of building under ground is reduced. (approximately 30 % smaller) 6. Area of building is reduced. **(Construction Cost)** 7. Construction cost of is estimated lower. Especially the cost of civil work is reduced to 70 % of **Option B**. **(Operation & Maintenance)** 8. O/M cost of mechanical equipment such as electrical power, is estimated lower because the device sizes are smaller.	Subjects are contrary to Disadvantage of **Option A**.
Disadvantage	
(Structure & Equipment Design) 1. Pump should be a solid permissible type to prevent jamming from larger solids. **(Construction Cost)** 2. Cost of pump equipment may be slightly higher owing to a special impeller of pump. **(Operation & Maintenance)** 3. More frequent maintenance is required. 4. O/M Cost may be increased by replacing the impeller and cleaning the pump.	Subjects are contrary to Advantage of **Option A**.

Considering the mentioned above, Option A is proposed an optimum one. Five (5) units of axial flow vertical type pump with a design capacity of 133.3 m^3/min./unit (2units) and 105.0 m^3/min./unit (3units) are installed. Grit chamber and screen are proposed after the pumping up.

15. Wastewater and Sludge Treatment Plant

15.1 Introduction

Conventional activated sludge system was proposed as the optimum wastewater treatment system for THBNDT basin. The preliminary design of the wastewater and sludge treatment plant for the target year 2010 is conducted in this section.

15.2 Treatment Plant Site

(1) Location

The proposed wastewater treatment plant site is located in Phuoc Loc Ward in Nha Be District. (Refer to Fig. F.14.1) The area of about 50 ha was allocated for wastewater treatment plant site by PCHCM. (Letter No. 2364/CV-UB-QLDT, June 19, 1999) This area is enclosed by Cay Kho river to the east and Go Nai river to the west.

(2) Land Elevation

The existing land elevation of this area ranges from + 0.3 m to + 1.3 m above mean sea level at Mui Nai. Land is almost flat. Hence, the area is covered by water with a depth of about 0.4 m in the high tide. The river bed elevation of Cay Kho canal at the proposed effluent discharging point is about -6.5 m, which is about 7.5 meter lower than the existing ground elevation of the proposed treatment plant site.

(3) Soil Condition

The area is expected to be covered by the alluvium of Saigon River delta at the top layer. Hence as could be expected the top surface layer of proposed treatment plant site is rather soft. Based on the soil investigation conducted by JICA Study Team, the base layer of the soil is not found until a depth of 30 meters from the ground surface. Deeper than 35 meters from the ground surface, the diluvial layer is found. The shallower alluvium layers consist of clay and sandy clay layers alternatively. The diluvial layers consist of sand and clayey sand. The characteristics of both alluvial and diluvial layers are described below.

Layer	Depth (m)	Nature of soil	SPT (N value)
1	8 ~ 26	Organic Clay	0 ~ 2
2	5 ~ 13	Organic Clay	2 ~ 4
3	6 ~ 13	Sandy Clay	2 ~ 4
4	2 ~ 4	Clayey Sand	4 ~ 6
5	1.5	Sand	6
6	1.5 ~ 2	Silty Sand	5 ~ 6
7	3 ~ 8.5	Silty Sand	10 ~ 15
8	4.5 ~ 12	Sand with Silt	10 ~ 19
9	8	Sand with Silt	8 ~ 10

15.3 Design Condition

15.3.1 Design Flow

Daily average wastewater discharge in dry weather flow including groundwater infiltration (10% of daily average discharge) in the year 2010 is applied for design of the treatment plant. The design flow of 469,000 m^3/day consisting wastewater of 426,500 m^3/day and groundwater of 42,500 m^3/day is applied as dry weather flow. The design wastewater discharge of the respective sewerage sub-zone is shown in the table presented in Section 1.2 of this Chapter.

The wet weather flow of 1.4 times of dry weather discharge plus groundwater infiltration is used for design of lift pumping station and effluent facility.

15.3.2 Design Influent and Effluent Water Quality

Design influent wastewater quality consisting of toilet waste and gray water in future of 2010 is estimated at 180 mg/l in terms of BOD_5 (from unit per capita pollution load of 55 g/day in terms of BOD_5 and unit per capita wastewater discharge of 300 l/day) and 200 mg/l of SS.
Design effluent water quality is proposed to be 50 mg/l in terms of BOD_5 in the year 2010. Based on the Vietnamese water quality standards (TCVN5945-1995, TCXD188-1996), the required effluent water quality from the treatment plant to Cay Kho river is 50 mg/l of BOD_5. While in the future, the required wastewater treatment level is easily expected to be graded up. In the light of this fact, 20 mg/l in terms of BOD_5 is proposed as the effluent water quality in future 2020.

15.4 Preliminary Design of Wastewater Treatment Plant

Preliminary design of wastewater treatment plant with a capacity of 469,000 m^3/day was conducted. The proposed layout of the conventional activated sludge treatment plant and flow sheet of the system are shown in Figs. F.15.1 and F.15.2.

15.4.1 Design Criteria

No design criteria of wastewater treatment and sludge treatment are available in Vietnam. To establish the design criteria of this project, design criteria proposed by Design Manuals were studied. The Design Manuals being used as references are as follows:

- Wastewater Engineering (Metcalf /Eddy) (W/E)
- WEF Manual of Practice No.8 & ASCE Manual and Report on Engineering Practice No. 76 (WEF)
- Japanese Design manual on Wastewater Treatment (JDM)

The results of the comparative study of design criteria are summarized in Table F.14.1. Based on the comparative study, design criteria used for this project are described below:

(1) Primary Sedimentation Basin

Parameter	Design Criteria	References
Over flow rate	35 $m^3/m^2/d$ 25 ~ 50 $m^3/m^2/d$ *	W/E JDM
Removal efficiency	SS = 40%	JDM

Note: * means that a criterion is used for design of primary sedimentation basin for combined sewer system.

(2) Aeration Tank

Parameter	Design Criteria	References
F/M ratio	0.3	W/E & WEF
Activated sludge recirculation ratio	0.35	W/E & WEF
MLSS	1,200 ~ 3,000 mg/l	W/E, WEF & JDM
Hydraulic detention time	4 ~ 10 hrs	W/E, WEF & JDM

(3) Secondary Sedimentation Basin

Parameter	Design Criteria	References
Over flow rate	25 $m^3/m^2/d$	W/E, WEF & JDM

(4) Disinfection

Parameter	Design Criteria	References
Dozing rate	5 mg/l 2 ~ 4 mg/l	W/E JDM

15.4.2 Structural Design

(1) Lift Pumping Station

- Design Flow : 445 m^3/min. (design wet weather flow of 640,000 m^3/day)
- Detention Time of Pump Pit : 2.8 minutes
- Dimension of Pump Pit : 26 m (L) x 12 m (W) x 4.0 m (H)
- No. of Pump : 5 units (include 1 stand-by)
- Type of Pump : Axial Flow Vertical Pump (112 m^3/min. x 20 m (h) x 400 kw)

(2) Primary Sedimentation Basin

Salient Features of Primary Sedimentation Basin are as follows:

- Design Flow : 469,000 m^3/day
- Effective Depth : 3.75 m
- Dimension of Basin : 7 m (W) x 51 m (L) x 4.5 m (H) (for 1 unit)
- Weir Length : 79 m
- No. of Basin : 48 units
- Sludge Collector : Flight chain type x 48 units
- Sludge Drawing Pump : 0.2 m^3/min. x 15 m x 3.75 kw x 24 units (plus 12 units as stand-by)

Hydraulic detention time of primary sedimentation basin is 3.75 hours with an overflow rate of 27.4 m^3/m^2/day. Proposed primary sedimentation basin is shown in Fig. F.15.4.

(3) Aeration Tank

Salient features of aeration tank are described below:

- Effective Depth : 5 m
- Dimension of Tank : 63 m (L) x 7 m (W) x 6 m (D) x 48 units
- Blower : 580 m^3/min. x 6.3 mAq x 800 k @ 5 units (including 1 stand-by)

Hydraulic detention time is 6.2 hours and sludge recirculation ratio is 54 %. Diffused type aeration is installed in the aeration tank. Proposed aeration tank is shown in Fig. F.15.5.

(4) Secondary Sedimentation Basin

Salient features of secondary sedimentation basin are described below:

- Effective Depth	:	4.5 m
- Dimension of basin	:	76.5 m (L) x 7 m (W) x 5.25 m (D) @ 48 units
- Weir Length	:	79 m per unit
- Sludge Collector	:	Flight chain type x 48 units
- Sludge drawing pump	:	15 m^3/min. x 10 m x 45 kw x 24 units (plus 12 units as stand-by)

Hydraulic detention time is 6.75 hours with an overflow rate of 18.2 $m^3/m^2/d$. Proposed secondary sedimentation basin is shown in Fig. F.15.6.

(5) Disinfection Tank

Salient features of disinfection tank are described below:

- Effective Depth of Tank	:	4 m
- Dimension of Tank	:	67 m (L) x 25 m (W) 4.5 m (D) @1 unit

Hydraulic detention time of disinfection tank is 18.8 min. Chlorine injection rate of 3 mg/l is proposed. Proposed disinfection facility is shown in Fig. F.15.7.

15.5 Sludge Treatment

15.5.1 General

Selection of sludge treatment system should go hand in hand with the selection of the liquid treatment system. A typical sludge treatment process is shown in Fig. F.15.8. Sludge treatment process is usually achieved in four (4) steps as thickening, stabilization, dewatering and disposal. Thickening process reduces the volumetric loading to and increases the efficiency of, subsequent solids processing steps. Stabilization process is usually required to stabilize the organic material in the sludge and to destroy pathogenic bacteria, to make it suitable for final disposal. Stabilization process can be avoided if sanitary landfill is adopted as the final disposal. Dewatering is used to reduce the moisture content of the sludge so that it can be easily handled and disposed off.

15.5.2 Sludge Thickening

Thickening process is selected depending on the characteristics of the sludge. Generally, two (2) types of sludge are produced at the wastewater treatment plant; primary sludge consists organic solids, grit, and inorganic fines discharged from primary sedimentation basin and secondary sludge, i.e., biological sludge consisting of the conventional products from soluble wastes in primary effluent and particles escaping primary treatment. The primary sludge is slimy and easy to thicken however biological sludge is generally more difficult to thicken or dewater.

Following two (2) systems of sludge thickening are applied for this project.

- Gravity thickening for primary sludge
- Centrifugal thickening for secondary sludge

15.5.3 Sludge Stabilization

In this project, following three (3) sludge stabilization processes are studied:

- Anaerobic Digestion
- Aerobic Digestion
- Composting

(1) Anaerobic Digestion

Anaerobic digestion has been and continues to be one of the most widely used processes for the stabilization of wastewater treatment sludge, and has the following advantages:

- Required energy for operation is just limited for mixing the anaerobic digestion tank
- High rate of pathogens destruction
- Production of electric power by methane can cover from 20% to 30% of electric consumption at the treatment plant
- Reduction of 30% to 40% of sludge volume requiring ultimate disposal
- Sludge is suitable for land disposal

The required detention time of anaerobic digestion tank is more than 20 days under the temperature of 30°C to 35°C. And biogas produced from the anaerobic processing of sludge should be collected either for use or for burning to avoid odor. However, this digester gas handling system requires intricate devices. These complications lead the following disadvantages:

- Required skilled operators
- High initial cost requirement
- Supernatant strong in BOD, COD, SS, and NH_3

The rough cost estimation to construct the anaerobic digestion tank for this project, billion VND is required. Then, anaerobic digestion system is not proposed for this project.

(2) Aerobic Digestion

Aerobic digestion is the process, which is used for stabilization of sludge in small plants. Usually this process is used to stabilize sludge from extended aeration or nitrification system where sludge has already longer sludge retention time (SRT) of the order of 20 days. The primary sludge, which has comparatively smaller SRT, may not be fully stabilized by aerobic digestion process. Hence for primary sludge, aerobic digestion process is not recommended.

The advantages of aerobic digestion compared to anaerobic digestion process are listed below:

- Lower initial cost requirement
- Lower BOD concentration in supernatant
- Operation is relatively easy

Disadvantages of aerobic digestion are as follows:

- Higher power cost requirement for association with supplying the required oxygen
- Digested sludge is produced with poor mechanical dewatering characteristics

Hence aerobic digestion process is not proposed for this project.

(3) Composting

Composting process is recommended for this project from the following reasons:

- Low initial investment cost
- Sludge treated by the composting process is easily utilized as the fertilizer and land reclamation
- Operation and maintenance are relatively easier than other stabilization processes

15.5.4 Sludge Dewatering

Natural and mechanical dewatering processes are employed dewatering sludge discharged from the wastewater treatment plant. Sand drying beds and drying lagoon are main systems of natural dewatering process. Sludge lagoon is not recommended for unstabilized sludge. Belt filter press is the most commonly used mechanical dewatering process. Belt filter press is recommended as the sludge dewatering process for this project.

15.6 Preliminary Design of Sludge Treatment Plant

Preliminary design of sludge treatment plant with a capacity of 512,000 m^3/day wastewater treatment was conducted. The flow diagram is shown in Fig. F.15.2. The proposed layout of the sludge treatment plant is shown in Fig. F.15.1.

15.6.1 Design Criteria

No design criteria of sludge treatment are available in Vietnam. To establish the design criteria of this project, design criteria proposed by Design Manuals were studied. The Design Manuals being used as references are as follows:

- Wastewater Engineering (Metcalf/Eddy) (W/E)
- WEF Manual of Practice No.8 & ASCE Manual and Report on Engineering Practice No. 76 (WEF)
- Japanese Design manual on Wastewater Treatment (JDM)

The results of the comparative study of design criteria are summarized in Table F.14.2. Based on the comparative study, design criteria used for this project are described below:

(1) Gravity Thickener

Depending upon the sludge characteristics, solid loading and thickened sludge concentration are determined based on the design criteria of W/E and WEF as shown below.

Sludge Type	Item	Design Criteria
Primary Sludge	Raw sludge concentration	3.0%
	Thickened sludge concentration	6.0%
	Solid loading	110 kg/m^2/d
Primary & Activated Sludge	Raw sludge concentration	Primary = 3.0% Activated = 0.8%
	Thickened sludge concentration	3.0%
	Solid loading	kg/m^2/d

(2) Centrifugal Thickener

Centrifugal thickener is used for thickening activated sludge only. Raw sludge and thickened sludge concentration are reported as 0.8% and 6.0% respectively. The operation time recommended is 24 hrs/day and 80% of operation efficiency is expected.

15.6.2 Structural Design

(1) Gravity Thickener

Gravity thickener for treatment of primary sludge consists of storage tank and thickener. Design conditions are as follows:

- Sludge volume : 78.2 m^3/hr
- Sludge concentration : 2 %
- Solid loading : 90 kg/ m^2/day

Dimension of storage tank is of 5m (L) x 5m (W) x 3.5m (D) @1 unit with detention time of 1.1 hour. An agitator of 5.5 kw capacity is installed for sludge mixture.

Dimension of proposed gravity thickener is of 24 m (ϕ) x 4 m (H) x 2 units (including 1 stand-by) with solid loading of 83 kg/m^2/d.

Proposed gravity thickener is shown in Fig. F.15.9.

(2) Centrifugal Thickener

The preliminary design of centrifugal thickener for secondary sludge is conducted based on the following conditions:

- Secondary sludge : 63.35 ton/day
- Mass balance factor : 1.111
- Required treated sludge : 70.38 ton/day
- Sludge concentration : 0.8 %
- Required treated sludge volume : 8,798 m^3/day

Sludge concentration after centrifugal thickening is expected at 4%. Decanter type centrifugal thickener with a capacity of 1,067 kg/hr/unit is proposed. Then, three (3) units are required to thicken the secondary sludge with 24 hours operation. Another one (1) unit is proposed as stand-by.

Proposed layout of centrifugal thickener is shown in Fig. F.15.10.

(3) Sludge Dewatering

Belt filter press is preliminary designed based on the following conditions:

- Thickened primary sludge : 37,536 kg/day
- Thickened secondary sludge : 63,346 kg/day
- Solid concentration of both sludge : 4 %

- Required dewatered sludge volume : 2,522 m^3/day
- Effective filter width : 3 m
- Filtration rate : 87 kg/m/day
- Operation hour : 24 hours/day

Capacity of belt filter is estimated at 157 m^3/day/unit. Required number of belt filter press is 16. Another one (1) unit is proposed as stand-by. Solid concentration ratio of 20% is expected.

The proposed layout of belt filter press is shown in Fig. F.15.10.

(4) Composting

In this project, land disposal is proposed as the ultimate disposal, thus it is necessary to stabilize the sludge before disposal so as to reduce pathogens and odor.

EPA (Environmental Protection Agency in USA) established criteria for the use of processed sludge on agricultural land. After the sludge is treated by the treatment process to significantly reduce pathogens (PSRP) it can be applied to the agricultural land. Fig. F.15.11 shows the EPA regulation for using processed sludge on agricultural land.

The composting process is included in the category of the treatment process to further reduce pathogens, hence is proposed as an appropriate process for applying sludge of domestic wastewater to the agricultural land.

In this project, composting process dose not aim to produce good compost as a fertilizer in the market, is intend to reduce the volume of final disposal sludge and to stabilize in quality.

Proposed composting process consists of (1) preconditioning and (2) fermentation.

In the preconditioning process, dewatered sludge with 80% moisture contents is mixed with straw and dewatered again in the rotary kiln. The preconditioned sludge is transferred to the fermentation yard and left there for about 10 days with periodical mixing by shovel car. Proposed composting process is shown in Fig. F.15.2.

Compost will be transferred to the final dumping site for land reclamation.

16. Implementation Program of Priority Project

16.1 Project Phasing

The total project cost for the Priority Project of Sewerage Development for Tau Hu, Ben Nghe – Doi, Te Basin is estimated at 4,490 VND billion as shown in Appendix J. From the budgetary constraints, the Priority Project should be divided into two (2) phases.

16.2 Selection of the Priority Area

Sewerage development area is proposed to divide into 24 sub-zones. And 24 sub-zones are classified into four (4) integrated zones from their wastewater collection system. Eastern part of left bank of Ben Nghe canal consists of 10 sub–zones of No. 1,2,3,4,5,6,7,8,9 and 10. And Western part of left bank of Tau Hu canal consists of six (6) sub-zones of No. 11,12,13,14,15 and 16. Isolated area by both canals of Tau Hu, Ben Nghe and Doi, Te consists of five (5) sub-zones of Khanh Hoi, Ong Kieu, Hung Phu, Tung Thien Vuong and Binh. And Southern part of Doi, Te canals consists of three (3) sub-zones of Rach Ong, Pham The Hien and Binh Dang. Delineation of sewerage sub-zones into four (4) integrated zones are shown in Fig. F.16.1.

Priority sequences for implementation of the priority sewerage development are determined based on the aspects of demand/benefits and constraints of the respective zones.

Demand/benefits consists of population density, public land use and pollution load generation. Constraints consist of affordability of sewerage development and existing combined sewer coverage rate.

16.2.1 Demand and Benefits of Sewerage Development

(1) Population Density

Eastern part of left bank of Ben Nghe canal zone covers a center of Ho Chi Minh City with an area of 828.4 ha consisting of District 1, 3, 5 and 10. The existing and future populations are estimated at 442,070 in 1997 and 425,830 in 2010 respectively. Existing and future population density are 533 person/ha and 514 person/ha respectively.

Western part of Tau Hu canal covers an area of 865 ha with the existing and future population of 517,689 and 505,819. The existing and future population density are estimated at 598 person/ha and 584 person/ha.

The isolated zone covers an area of 561.5 ha with existing and future population of 360,828 and 338,291 respectively. The existing and future population density are at 643 person/ha and 602 person/ha.

The Southern zone of Doi, Te canals covers an area of 536.8 ha with existing and future population of 148,116 and 151,838 respectively, with population density of 276 person/ha and 283 person/ha.

High population density zone has higher priority for sewerage development because of high pollution load generation and relatively worse unsanitary condition, in principle.

The highest score of 4 gives the isolated zone with population density of more 600 person/ha. Next score of 3 gives to Western area of left bank of Tau Hu canal and score of 2 gives to Eastern part of left bank of Ben Nghe canal. And the lowest score of 1 gives to the Southern zone of Doi, Te canal.

(2) Public Land Use

Ratio of commercial and institutional area to the total sewerage development area is defined as public land use rate. Higher priority will be given to an integrated zone with high public land use rate (refer to Appendix B, Table B.3.1).

Integrated sub-zone	Public land Use ratio	Priority Index
Eastern part of left bank of Ben Nghe canal	24%	4
Western part of left bank of Tau Hu canal	11%	3
Isolated area	3%	2
Southern area of Doi, Te canal	2%	1

(3) Pollution Load Generation

Sewerage development contributes mitigation of pollution load discharge to the public water bodies with no treatment. Higher priority will be given to an integrated zone with high pollution load generation.

Integrated sub-zone	Pollution Load Generation (kg/day)		Priority Index
	Existing	Future	
East part of left bank of Ben Nghe canal	17,683	21,292	3
West part of left bank of Tau Hu canal	20,708	25,291	4
Isolated area	14,433	16,915	2
South area of Doi, Te canal	5,925	7,592	1

16.2.2 Constraints

(1) Affordability

Financial viability of the project depends on affordability of the users. Higher priority will be given to an integrated zone with high affordability of the users.

Based on the proposed sewerage tariff system described in Appendix L, higher sewerage tariff is levied on governmental offices, industrial establishments and commercial enterprises. Hence, the zone with high occupancy rate of these offices and enterprises has high sewerage tariff collection efficiency. Table F.16.1 shows sewerage tariff collection efficiency by each district, which is covered by the Priority Project. The integrated zone with high sewerage tariff collection efficiency is defined as the high affordability area for sewerage development.

Sewerage tariff collection efficiency of respective integrated sewerage zone estimated by multiplying sewerage tariff collection efficiency of each district by ratio of area covered by sewerage system to total district area. Table F.16.2 shows the point of sewerage tariff collection efficiency of each integrated sewerage zone.

The highest point of 127 is given to Eastern part of left bank of Ben Nghe canal with following Western part of Tau Hu canal of 123, isolated area of 62 and Southern area of Doi, Te canal of 5.

Integrated sub-zone	Tariff Collection Efficiency Point	Priority Index
Eastern part of left bank of Ben Nghe canal	127	4
Western part of left bank of Tau Hu canal	123	3
Isolated area	62	2
Southern area of Doi, Te canal	5	1

(2) Existing Combined Sewer Coverage Ratio

Higher priority will be given an integrated zone with high existing combined sewer coverage rate. Existing combined sewer coverage rate of respective integrated zones is shown below.

Integrated sub-zone	Sewerage Area (ha)	Existing Combined Sewer Coverage Area (ha)	Coverage Ratio (%)	Priority Index
Eastern part of left bank of Ben Nghe canal	828.4	828.4	100	4
Western part of left bank of Tau Hu canal	865.0	865.0	100	4
Isolated area	561.5			3
Southern area of Doi, Te canal	536.8			2

16.2.3 Integration of Priority Index

From the integration of above mentioned priority index, Eastern part of left bank area of Ben Nghe canal and Western part of left bank area of Tau Hu canal get the highest priority index of 17.

Integrated sub-zone	Priority Index
Eastern part of left bank of Ben Nghe canal	17
Western part of left bank of Tau Hu canal	17
Isolated area	13
Southern area of Doi, Te canal	6

While, Western part of left bank area of Tau Hu canal has only one (1) potential route of Tran Van Kieu and Ben Ham Tu roads along Tau Hu canal for interceptor sewer installation. These Tran Van Kieu and Ben Ham Tu roads will be expanded by the canal side roads expansion project after the relocation program along canals will be completed. Then, interceptor sewer of Western part of left bank area of Tau Hu canal should be constructed simultaneous with the canal side road expansion project. While the interceptor sewer for Eastern part of left bank area of Tau Hu, Ben Nghe canal can be constructed independently without any affection by other projects schedule. From this point of view, Eastern part of left bank area of Ben Nghe canal is selected as the Phase I Project area.

17. Selection of Appropriate Wastewater Treatment Process for The Phase I Project

17.1 General

In the Interim Report, JICA Study Team has conducted detailed comparison of various wastewater treatment processes for the Priority Project with the target year of 2020 and has proposed conventional activated sludge process as the most appropriate wastewater treatment process. The Priority Project is proposed to be implemented in two (2) phases. The Phase I with the target year of 2005 will improve the environmental condition of THBNDT zone immediately. Design conditions of Phase I Project are different from that of those studied at Master Plan Stage and about 50 ha of land is available for treatment plant. Hence, options for treatment process are reviewed again but keeping in mind that process chosen at Phase I could be smoothly switched to conventional activated sludge process proposed for the year of 2020.

17.2 Design Conditions

The design conditions for Phase I Project are described below:

Item	Phase I Project	Priority Project (2020)
Population Served	425,830	1,390,282
Design flow	141,000 m^3/d	512,000 m^3/d
Influent quality	BOD_5 = 180 mg/l	BOD_5 = 180 - 250 mg/l
Design effluent quality	BOD_5 = 50 mg/l	BOD_5 = 20 mg/l

(In Master Plan Stage at the year of 2020, effluent is proposed to have quality which meets the requirements of Category A as stipulated in TCVN 5947-1995, however for Phase I Project effluent is proposed to have quality which meets the requirements of Category B of above mentioned standards.)

17.3 Options of Wastewater Treatment Process

The process should ;

- be tolerant to bear the changes in inflow quality and quantity
- satisfy design effluent quality
- generate sludge which is easy to treat and dispose
- have low construction cost
- have low operation and maintenance requirements
- be in line with the process (Conventional Activated Sludge) proposed for the Priority Project

With due consideration to the hot weather of Ho Chi Minh City and scale of treatment plant required, processes which satisfy the above mentioned criteria are selected for evaluation and mentioned below.

- Stabilization pond
- Aerated lagoon
- Primary sedimentation + Stabilization pond
- Modified activated sludge

Besides the above-mentioned processes, activated sludge process and primary sedimentation are supplementary included in the alternative study to have a better comparison of cost/performance ratio of these processes. Oxidation ditch and Bio-film processes such as Rotating Biological Contactor, Contact Oxidation and Bio-film filter are generally not recommended for large-scale plant and not included in the alternative study. For sludge drying process, sludge drying bed and belt filter press are compared.

The four (4) alternatives with three (3) supplementary processes studied for the wastewater and sludge treatment process are shown below in the table. Basically alternatives consist of Pond processes and Activated Sludge Processes. Proposed layouts of each alternative are shown in Fig. F.17.1 to Fig. F.17.7.

Alternatives of Wastewater and Sludge Treatment Process

Alternative	Wastewater Treatment Process	Sludge Treatment Process	Expected Effluent BOD_5 mg/l
1	Stabilization Pond	Drying Bed	50
2	Aerated Lagoon	Drying Bed	50
3	Primary Sedimentation + Stabilization Pond	Drying Bed	50
4	Modified Activated Sludge	Belt Filter Press	50
(S-1)	Conventional Activated Sludge	Drying Bed	20
(S-2)	Conventional Activated Sludge	Belt Filter Press	20
(S-3)	Primary Sedimentation	Drying Bed	125

17.4 Evaluation of Alternatives

The above-mentioned four (4) alternatives are evaluated for the following criteria:

- Construction cost/Removal BOD_5
- Facility maintenance
- Operation technology
- Maintenance cost
- Required area
- Excess sludge generation
- Adaptability to variation in quality and quantity of inflow
- Effluent quality
- Environmental aspects
- Initial performance
- Smoothness of switching to conventional activated sludge process with bigger capacity in the Final Stage

Dimensions of pumping station, control & electric equipment room, disinfection tank, disinfection facility room are the same for all alternatives. Hence these are ignored for comparative study. The dimensions of blower room and dewatering equipment room in modified activated sludge process for the Phase I Project is the same as that in the Final Stage. As for mechanical equipment, numbers of machines are estimated as required in Phase I Project. These will be increased step by step towards the Final Stage. Considering the time to switch to conventional activated sludge process as proposed in the Master Plan, minimum spaces for the facilities are kept.

Detailed evaluation of these alternatives is presented in Table F.16.1 to Table F.16.6. Pond processes are more economical compared with modified activated sludge process. It is not easy to convert pond process to conventional activated sludge process, which means dual investment will be necessary. Pond processes have quite often smell problem. Furthermore in case of process failure, pond processes need 2-3 months to recover with comparison to 2 weeks for modified activated sludge process.

Modified activated sludge process which has cost efficiency to BOD_5 removal quite close to pond processes, high tolerance to variation of inflow quality and quantity, easy convertibility to Final Stage Process and effluent conforming to Vietnamese standards, is recommended for the Phase I Project.

Table F.1.1 DOMESTIC WASTEWATER GENERATION BY DISTRICTS

Year	1997			2020		
	Population (person)	Unit Wastewater Daily Ave. (L/person/day)	Wastewater Daily Ave. (m3/day)	Population (person)	Unit Wastewater Daily Ave. (L/person/day)	Wastewater Daily Ave (m3/day)
Total of Study Area	**4,416,638**	**161**	**711,370**	**7,430,985**	**278**	**2,071,050**
Urban Area	**3,541,040**	**170**	**601,977**	**4,000,000**	**335**	**1,340,000**
District 1	282,063	170	47,951	270,000	335	90,450
District 3	260,418	170	44,271	250,000	335	83,750
District 4	220,650	170	37,511	210,000	335	70,350
District 5	251,387	170	42,736	220,000	335	73,700
District 6	280,336	170	47,657	300,000	335	100,500
District 8	347,090	170	59,005	430,000	335	144,050
District 10	271,593	170	46,171	270,000	335	90,450
District 11	260,159	170	44,227	250,000	335	83,750
Go Vap	234,966	170	39,944	450,000	335	150,750
Tan Binh	512,185	170	87,071	600,000	335	201,000
Binh Thanh	417,739	170	71,016	520,000	335	174,200
Phu Nhuan	202,454	170	34,417	230,000	335	77,050
New Urban Area	**611,669**	**140**	**85,634**	**2,270,000**	**253**	**574,310**
District 12	127,459	140	17,844	450,000	253	113,850
Thu Duc	171,165	140	23,963	500,000	253	126,500
District 2	95,219	140	13,331	600,000	253	151,800
District 9	119,446	140	16,722	400,000	253	101,200
District 7	98,380	140	13,773	320,000	253	80,960
Rural Area	**263,929**	**90**	**23,754**	**1,160,985**	**135**	**156,733**
Hoc Mon	34,241	90	3,082	99,244	135	13,398
Binh Chanh	185,378	90	16,684	977,241	135	131,928
Nha Be	44,310	90	3,988	84,500	135	11,408

(Remarks)

1. Water consumption = Domestic Wastewater Generation
2. Ignore underground water infiltration

Table F.1.2 DOMESTIC POLLUTION GENERATION BY DISTRICT

Year	1997			2020		
	Population (person)	BOD_5 Unit Load (g/person/day)	BOD_5 Load (kg/day)	Population (person)	BOD_5 Unit Load (g/person/day)	BOD_5 Load (kg/day)
Total of Study Area	**4,416,638**	**38**	**169,650**	**7,430,985**	**51**	**382,790**
Urban Area	**3,541,040**	**40**	**141,642**	**4,000,000**	**60**	**240,000**
District 1	282,063	40	11,283	270,000	60	16,200
District 3	260,418	40	10,417	250,000	60	15,000
District 4	220,650	40	8,826	210,000	60	12,600
District 5	251,387	40	10,055	220,000	60	13,200
District 6	280,336	40	11,213	300,000	60	18,000
District 8	347,090	40	13,884	430,000	60	25,800
District 10	271,593	40	10,864	270,000	60	16,200
District 11	260,159	40	10,406	250,000	60	15,000
Go Vap	234,966	40	9,399	450,000	60	27,000
Tan Binh	512,185	40	20,487	600,000	60	36,000
Binh Thanh	417,739	40	16,710	520,000	60	31,200
Phu Nhuan	202,454	40	8,098	230,000	60	13,800
New Urban Area	**611,669**	**35**	**21,408**	**2,270,000**	**45**	**102,150**
District 12	127,459	35	4,461	450,000	45	20,250
Thu Duc	171,165	35	5,991	500,000	45	22,500
District 2	95,219	35	3,333	600,000	45	27,000
District 9	119,446	35	4,181	400,000	45	18,000
District 7	98,380	35	3,443	320,000	45	14,400
Rural Area	**263,929**	**25**	**6,598**	**1,160,985**	**35**	**40,634**
Hoc Mon	34,241	25	856	99,244	35	3,474
Binh Chanh	185,378	25	4,634	977,241	35	34,203
Nha Be	44,310	25	1,108	84,500	35	2,958

(Remarks)

1. Water consumption = Domestic Wastewater Generation
2. Ignore underground water infiltration

Table F.2.1 EXISTING SERVICE POPULATION RATIO BY SANITATION FACILITY

DISTRICT	EXISTING POPULATION	NUMBER OF HOUSEHOLD	TOILET WITH STANDARD S/T		TOILET WITH UNSTANDARD S/T		LEACHING PIT		HANG-ON TOILET		NO FACILITY	
			NUM. OF HH	%	NUM.OF HH	%	NUM.OF HH	%	NUM.OF HH	%	NUM.OF HH	%
1	280,063	31,628	28,525	90.19	0	0.00	0	0.00	1,607	5.08	70	0.22
3	260,418	32,261	20,210	62.65	8,502	26.35	0	0.00	1,666	5.16	922	2.86
4	220,650	33,156	17,556	52.95	1,056	3.18	0	0.00	3,356	10.12	5,708	17.22
5	251,387	28,471	26,519	93.14	1,420	4.99	0	0.00	264	0.93	una	una
6	280,336	27,830	7,069	25.40	13,784	49.53	0	0.00	4,250	15.27	2,077	7.46
8	347,090	42,715	25,489	59.67	0	0.00	0	0.00	7,411	17.35	una	una
10	271,593	35,118	34,969	99.58	0	0.00	una	una	149	0.42	una	una
11	260,159	35,878	34,808	97.02	0	0.00	0	0.00	556	1.55	514	1.43
GO VAP	234,966	27,375	9,548	34.88	15,397	56.24	17	0.06	192	0.70	2,239	8.18
TAN BINH	512,185	59,047	15,381	26.05	42,346	71.72	10	0.02	1,608	2.72	648	1.10
BINH THANH	417,739	56,467	44,544	78.89	1,678	2.97	0	0.00	3,377	5.98	una	una
PHU NHUAN	202,454	28,853	27,348	94.78	0	0.00	0	0.00	204	0.71	una	una
12	127,459	una	una	una	una	una	una	una	una	una	una	una
HOC MON	185,817	54,206	0	0.00	21,414	39.50	una	una	14,000	25.83	6,331	11.68
THU DUC	171,165	27,164	0	0.00	26,626	98.02	una	una	una	una	una	una
2	95,219	14,478	7,631	52.71	473	3.27	143	0.99	1,990	13.74	una	una
9	119,446	una	una	una	una	una	una	una	una	una	una	una
7	98,380	una	una	una	una	una	una	una	una	una	una	una
BINH CHANH	263,883	44,152	5,197	11.77	11,804	26.73	0	0.00	8,010	18.14	9,122	20.66
Total	4,600,409	578,799	304,794	52.66	144,500	24.97	170	0.03	48,640	8.40	27,631	4.77

Source: Center for City Preventive Medication, 1997

Note : una : unavailable

Table F.2.2 NUMBER OF EXISTING PUBLIC TOILET IN HOCHIMINH CITY

DISTRICT	NUMBER OF EXISTING P/T		P/T ON MARKETS & BUS STA.		P/T ON STREETS		P/T FOR RECIDENCE		CHARGE
	NUM.	SEAT	NUM.	SEAT	NUM.	SEAT	NUM.	SEAT	PER TIME (VND)
1	19	202	10	120	9	82	0	0	300
3	19	193	2	15	0	0	17	178	300-500
4	4	55	2	20	0	0	2	35	500
5	6	52	2	20	3	24	1	8	500
6	7	97	3	34	0	0	4	63	500
8	14	143	5	54	0	0	9	89	300
10	4	34	2	21	2	13	0	0	300-500
11	4	28	3	26	0	0	1	2	500
GO VAP	1	8	1	8	0	0	0	0	200
TAN BINH	10	87	10	87	0	0	0	0	200-300
BINH THANH	10	151	6	62	0	0	4	89	300-500
PHU NHUAN	10	74	4	20	0	0	6	54	200-500
12	4	24	2	12	2	12	0	0	200
HOC MON	5	29	2	15	1	6	2	8	200
THU DUC	6	36	4	24	2	8	0	0	500
2	3	18	2	13	1	5	3	0	500
9	1	4	1	4	0	0	0	0	500
7	2	12	2	12	0	0	0	0	una
BINH CHANH	6	80	5	68	0	0	1	12	200-500
TOTAL	135	1.33	68	635	20	150	50	538	

Source: The Urban Environental Company, 1998

Table F.3.1 Construction and O&M costs of Sewerage System

Construction Cost

	Effluent BOD_5 : 50 mg/L					Effluent BOD_5 : 20 mg/L			
	Population Density (person/ha)	WWTP (USD/person)	Total Sewer (USD/person)	Pumping Station (USD/person)	Total (USD/person)	WWTP (USD/person)	Total Sewer (USD/person)	Pumping Station (USD/person)	Total (USD/person)
Case 1	29	47	381	264	692	55	381	264	700
Case 2	75	85	260	168	467	46	260	168	474
Case 3	118	59	212	57	328	69	212	57	339
Case 4	169	52	180	45	278	62	180	45	287
Case 5	218	52	160	33	246	61	160	33	255
Case 6	274	83	144	13	240	97	144	13	255
Case 7	330	81	132	11	224	95	132	11	239
Case 8	362	96	127	9	231	112	127	9	248
Case 9	413	102	119	6	226	119	119	6	244
Case 10	481	112	111	4	226	132	111	4	246

O&M Cost

	Effluent BOD_5 : 50 mg/L					Effluent BOD_5 : 20 mg/L			
	Population Density	WWTP	Total Sewer	Pumping Station	Total	WWTP	Total Sewer	Pumping Station	Total
	(person/ha)	(US dollar/person/year)				(US dollar/person/year)			
Case 1	29	2.2	1.0	0.2	3.3	3.1	1.3	0.2	4.6
Case 2	75	1.8	0.8	0.1	2.7	2.5	1.1	0.1	3.7
Case 3	118	2.8	1.2	0.2	4.2	3.9	1.7	0.2	5.8
Case 4	169	2.5	1.1	0.2	3.7	3.4	1.5	0.2	5.1
Case 5	218	2.5	1.1	0.2	3.7	3.4	1.5	0.2	5.1
Case 6	274	4.0	1.8	0.3	6.1	5.6	2.4	0.3	8.4
Case 7	330	3.9	1.7	0.3	6.0	5.5	2.3	0.3	8.2
Case 8	362	4.7	2.0	0.4	7.1	6.6	2.8	0.4	9.8
Case 9	413	5.1	2.2	0.4	7.7	7.1	3.0	0.4	10.6
Case 10	481	5.7	2.5	0.5	8.6	7.9	3.4	0.5	11.8

Table F.3.2 Construction and O&M Costs of On-site Sanitation System

Construction Cost

		Effluent BOD_5 : 50 mg/L				Effluent BOD_5 : 20 mg/L			
	Population Density (person/ha)	Purchase (USD/person)	Installation (USD/person)	Sludge Tratment Plant (USD/person)	Total (USD/person)	Purchase (USD/person)	Installation (USD/person)	Sludge Tratment Plant (USD/person)	Total (USD/person)
Case 1	29	107	21	16	144	214	21	16	251
Case 2	75	112	22	13	148	224	22	13	260
Case 3	118	127	25	20	172	254	25	20	300
Case 4	169	120	24	17	161	240	24	17	281
Case 5	218	117	23	17	157	233	23	17	274
Case 6	274	134	27	28	189	268	27	28	323
Case 7	330	134	27	27	188	268	27	27	322
Case 8	362	149	30	32	210	297	30	32	359
Case 9	413	134	27	34	195	269	27	34	329
Case 10	481	134	27	37	198	268	27	37	332

O&M Cost

		Effluent BOD_5 : 50 mg/L					Effluent BOD_5 : 20 mg/L				
	Population Density	Power	Chemical	Cleaning	Sludge Treatmen	Total	Power	Chemical	Cleaning	Sludge Treatmen	Total
	(person/ha)	(US dollar/person/year)					(US dollar/person/year)				
Case 1	29	0.0	0.4	1.5	1.5	3.4	4.0	0.4	1.5	1.5	7.5
Case 2	75	0.0	0.4	1.6	1.3	3.3	4.2	0.4	1.6	1.3	7.5
Case 3	118	0.0	0.5	1.8	2.0	4.2	4.7	0.5	1.8	2.0	9.0
Case 4	169	0.0	0.4	1.7	1.7	3.9	4.5	0.4	1.7	1.7	8.3
Case 5	218	0.0	0.4	1.6	1.7	3.8	4.3	0.4	1.7	1.7	8.2
Case 6	274	0.0	0.5	1.9	2.8	5.2	5.0	0.5	1.9	2.8	10.2
Case 7	330	0.0	0.5	1.9	2.8	5.1	5.0	0.5	1.9	2.8	10.2
Case 8	362	0.0	0.5	2.1	3.3	5.9	5.5	0.5	2.1	3.3	11.5
Case 9	413	0.0	0.5	1.9	3.6	6.0	5.0	0.5	1.9	3.6	11.0
Case 10	481	0.0	0.5	1.9	4.0	6.4	5.0	0.5	1.9	4.0	11.4

Table F.3.3 RELATION BETWEEN PROJECT COST AND POPULATION DENSITY

Effluent Water Quality BOD_5 : 50 mg/L

	Population Density (Person/ha)	Sewerage System			On-site Sanitaion System		
		Construction cost	O&M Cost	Total Cost	Construction Cost	O&M Cost	Total Cost
		(USD/person)			(USD/person)		
Case 1	29	692	31	723	144	32	177
Case 2	75	467	26	493	148	31	179
Case 3	118	328	40	368	172	40	212
Case 4	169	278	35	313	161	36	198
Case 5	218	246	35	281	157	36	193
Case 6	274	240	58	298	189	49	238
Case 7	330	224	56	281	188	48	236
Case 8	362	231	67	299	210	56	266
Case 9	413	226	73	299	195	56	251
Case 10	481	226	81	308	198	60	258

Effuent Water Quality BOD5 : 20 mg/l

	Population Density (Person/ha)	Sewerage System			On-site Sanitaion System		
		Construction Cost	O&M Cost	Total Cost	Construction cost	O&M Cost	Total Cost
		(USD/person)			(USD/person)		
Case 1	29	700	43	743	251	70	322
Case 2	75	474	35	509	260	70	330
Case 3	118	339	54	393	300	85	384
Case 4	169	287	48	336	281	79	360
Case 5	218	255	48	303	274	77	351
Case 6	274	255	79	333	323	96	419
Case 7	330	239	77	316	322	96	418
Case 8	362	248	92	340	359	108	467
Case 9	413	244	100	344	329	104	433
Case 10	481	246	111	357	332	107	440

Table F.4.1 Wastewater Treatment Plant Sites proposed by other Projects

Project Name	WWTP No. [1)]	Name	Ward	District	Near Canal	Land Use	Available Land Area	Unit Land Price
HCMC	1	Nha Be	Long Thoi	Nha Be	Kinh River	Present : Agriculture Future : Green Area	100 - 120 ha	19,300 VND/m^2
	2	Can Guioc	Hung Long	Binh Chanh	Can Guioc Canal	Present : Agriculture Future : Agriculture	50 - 65 ha	19,300 VND/m^2
	3	Cat Lai	Thanh My Lo	District 2	Don Nai River- Ky Ha Canal	Present : Agriculture Future : Green Area	50 - 65 ha	19,300 VND/m^2
	4	Vinh Loc A	Vinh Loc A	Binh Chanh	(Irrigation Canal) (no name)	Present : Agiricultural Area Future : Agricultural Area	50 - 65 ha	19,300 VND/m^2
Tau Hu - Doi-Te	5	Ong Nho	Ward 4	District 8	Ong Nho Canal	Present : Agriculture Future : Culture Area	-	19,300 VND/m^2
	6	Phu Dinh	Ward 14	District 8	Lo Gom Canal	Present : Residential Area Future : High Residential Area	-	72,000 VND/m^2
Tan Hoa-Ong Buong-Logom	7	Phu Dinh	Ward 14	District 8	Lo Gom Canal	Present : Residential Area Future : High Residential Area	-	72,000 VND/m^2
Nhieu Loc-Thi Nghe	8	Van Thanh	Ward 22	Binh Thanh	Thi Nghe Canal	Present : Residential Area Future : High Residential Area	-	210,000 VND/m^2
	9	Mieu Canal	Ward 22	Binh Thanh	Thi Nghe Canal	Present : Green Space Future : Relocation Area	-	128,000 VND/m^2

(Remarks)

1) Number in Fig. F.9, showing the location and project.

Table F.4.2 POTENTIAL SITES OF WASTEWATER TREATMENT PLANT

No.	Location	Area (ha)	Unit Price (VND/m2)	Ownership	Present Land Use	Future Land Use
1	Enclosed by Tan Ky - Tan Quy Str. & May 19 Canal & Binh Long Str.	60	-	government	Agricultural area with low population density	Green area
2	Enclosed by Le Minh Xuan st.. & Ba Goc Canal	160	38.600	private	Agricultural Area	Agricultural area
3 .	Enclosed by Ba Tang Canal & Ba Lon Canal.	70	19.300	private	Agricultural area	Green area
4	Southern of Saigon South (between Ba Lao Canal and Xom Cui Canal)	75	19.300	private	Agricultural area	Green area
5	Southern of Saigon South (enclosed by Tac Ben Ro Canal and Cay Kho Canal)	70	38.600	private	Agricultural area	Agricultural area
6	Enclosed by Roi Canal, far from Vinh Phuoc st. about 500m	150	26.000	private	Agricultural area	Agricultural area
7	Thanh Da area (Southern of proposed tourist area, near Saigon River)	50	256.000	private	Rice field with low population density	Green area
8	Enclosed by Luong Dinh Cua Str & Giong Ong To River & Saigon River.	15	19.300	private	Agricultural area	Green area
9	Near Ben Do Nho River and Ben Do Lon River.	90	19.300	private	Agricultural area	Green area
10	Near Cau Ong Nhieu canal and Dong Nai River	80	19.300	private	Agricultural area	Green area

Table F.5.1 Individual Small Scale Sewerage Development System

Sewerage Zone	Area (ha)		Population		Gross Population Density (person/ha)		Net Population Density (person/ha)	
	Gross	Net	1997	2020	1997	2020	1997	2020
West Zone								
TLBC	1,495	1,116	185,696	354,857	124	237	166	318
NLTN	3,935	3,084	1,217,258	1,359,569	309	346	395	441
THLG	2,447	1,946	542,108	655,540	222	268	279	337
THBNDT	3,065	2,236	1,468,703	1,390,282	479	454	657	622
SW	1,315	1,186	97,782	398,000	82	336	82	336
SS	1,555	1,162	91,880	320,000	79	275	79	275
Sub-total	13,812	10,730	3,603,427	4,478,248	261	324	336	417
East Zone								
SN-I	2,324	1,968	171,165	500,000	74	215	87	254
SN-II	1,152	1,027	63,410	196,500	55	171	62	191
SE-I	1,107	976	45,100	400,000	41	361	46	410
SE-II	583	539	23,000	200,000	39	343	43	371
Sub-total	5,166	4,510	302,675	1,296,500	59	251	67	287
ToTal	18,978	15,240	3,906,102	5,774,748	206	304	256	379

Note : Net Area = Gross Area - (Agricultural Area + Green Space + Other Areas)

Table F.5.2 Design Wastewater Discharge

Sewerage Zone	Area (ha)	Population 2020	Wastewater Discharge Daily Ave. (m3/day)	Groundwater Infiltration (m3/day)	Storm Water Infiltration (m3/day)	Design Wastewater Discharge (m3/day)	
						Dry Weather	Wet Weather
Inner City Area							
TLBC	1,495	354,857	118,877	11,888	47,551	131,000	178,316
NLTN	3,935	1,359,569	455,456	45,546	182,182	501,000	683,183
THLG	2,447	655,540	219,606	21,961	87,842	242,000	329,409
THBNDT	3,065	1,390,282	465,744	46,574	186,298	512,000	698,617
Sub-total	10,942	3,760,248	1,259,683	125,968	503,873	1,386,000	1,889,525
New Developed Area							
SW	1,315	398,000	100,694	10,069	-	111,000	-
SS	1,555	320,000	80,960	8,096	-	89,000	-
SN-I	2,324	500,000	126,500	12,650	-	139,000	-
SN-II	1,152	196,500	49,715	4,971	-	55,000	-
SE	1,690	600,000	151,800	15,180	-	167,000	-
Sub-total	8,036	2,014,500	509,669	50,967	0	561,000	0
Total	18,978	5,774,748	1,769,352	176,935	503,873	1,947,000	1,889,525

Table F.5.3 Sewer Length by Each Sewerage Zone

Sewerage Zone	Secondary/Tertiary		Main		Interceptor		Conveyance		Total Length
	Diameter (mm)	Length (m)	Diameter (mm)	Length (m)	Diameter (mm)	Length (m)	Diameter (mm)	Length (m)	(m)
Inner City									
THBNDT		-		-	500 - 2,500	34,750	3,000	3,169	37,919
MLTN		-		-	500 - 2,500	32,033	3,000	9,358	41,391
THLG		-		-	800 - 2,000	16,305	2,500	6,564	22,869
TLBC		-		-	700 - 1,600	9,356	1,600	635	9,991
Sub-Total of Inner City						92,444		19,726	112,170
New Developed Districts									
SW	150- -500	63,120	600 - 1,100	143,066			1,100	2,899	209,085
SS	150- -500	71,424	600 - 1,100	165,168					236,592
SN-1	150- -500	101,472	600 - 1,100	234,654					336,126
SN-2	150- -500	55,296	600 - 1,100	127,872					183,168
SE	150- -500	81,120	600 - 1,100	187,590					268,710
Sub-Total of New Developed Districts		372,432		858,350				2,899	1,233,681
Grand Total		372,432		858,350		92,444		22,625	1,345,851

Table F.5.4 Two Large Scale and Two Small Scale Treatment System

Sewerage Zone	Area (ha)		Population		Gross Population Density (person/ha)		Net Population Density (person/ha)	
	Gross	Net	1997	2020	1997	2020	1997	2020
West Zone								
Inner City Zone	10,942	8,382	3,413,765	3,760,277	312	344	407	449
SW	1,315	1,186	97,782	398,000	74	303	82	336
SS	1,555	1,162	91,880	320,000	59	206	79	275
Sub-total	13,812	10,730	3,603,427	4,478,277	261	324	336	417
East Zone								
New East Zone	5,166	4,510	302,675	1,296,500	59	251	67	287
Sub-total	5,166	4,510	302,675	1,296,500	59	251	67	287
Total	18,978	15,240	3,906,102	5,774,777	206	304	256	379

Net Area = Gross Area - (Agricultural Area +Green Space +Other Areas)

Table F.5.5 Sewer Length by Each Sewerage Zone

Sewerage Zone	Secondary/Tertiary		Main		Interceptor		Conveyance		Total Length
	Diameter (mm)	Length (m)	Diameter (mm)	Length (m)	Diameter (mm)	Length (m)	Diameter (mm)	Length (m)	(m)
Integrated Inner City		-		-	500 - 4,500	103,705	4,500	1,713	105,418
New Developed Districts									
SS	150 - 500	71,424	600 - 1,100	165,168		-		-	236,592
Intrgrated East	150 - 500	237,888	600 - 1,400	550,116		-		-	788,004
Sw	150 - 500	63,120	600 - 1,100	143,066		-	1,100	2,899	209,085
Sub-Total of New Developed Districts		372,432		858,350				2,899	1,233,681
Grand Total		372,432		858,350		103,705		4,612	1,339,099

Table F.6.1 Proposed Sewerage Development System

Sewerage Zone	Area (ha)		Population		Gross Population Density (person/ha)		Net Population Density (person/ha)	
	Gross	Net	1997	2020	1997	2020	1997	2020
West Zone								
TLBC	1,495	1,116	185,696	354,857	124	237	166	318
NLTN	3,935	3,084	1,217,258	1,359,569	309	346	395	441
THLG	2,447	1,946	542,108	655,540	222	268	279	337
THBNDT	3,065	2,236	1,468,703	1,390,282	479	454	657	622
SW	1,315	1,186	97,782	398,000	82	336	82	336
SS	1,555	1,162	91,880	320,000	79	275	79	275
Sub-total	13,812	10,730	3,603,427	4,478,248	261	324	336	417
East Zone								
SN-I	2,324	1,968	171,165	500,000	74	215	87	254
SN-II	1,152	1,027	63,410	196,500	55	171	62	191
SE	1,690	1,515	68,100	600,000	40	355	45	396
Sub-total	5,166	4,510	302,675	1,296,500	59	251	67	287
Total	18,978	15,240	3,906,102	5,774,748	206	304	256	379

Net Area = Gross Area - (Agricultural Area + Green Space + Other Areas)

Table F.6.2 Future Land Use in Respective Sewerage Developemnt Zone for 2020

(unit : ha)

Sewerage Zone	Residential area	Institutional Area	Green Space	Agricultural Area	Other Area	Total
THBNDT	1,121	1,115	120	0	705	3,061
NLTN	2,836	248	200	4	647	3,935
THLG	1,943	3	192	3	304	2,445
TLBC	1,089	27	114	4	260	1,494
SW	937	249	0	0	128	1,314
SS	1,109	53	131	0	264	1,557
SN-I	1,601	367	10	3	343	2,324
SN-II	975	52	0	0	125	1,152
SE	1,103	412	0	0	175	1,690
Total	12,714	2,526	767	14	2,951	18,972

Note : Residential area includes commercial and small industrial areas.
Other area consists of roads and water body.

Table F.6.3 Comparison of Treatment System

	Adaptability to Overload	Required O&M		Required Cost		Required Sludge Disposal		Required Land Acquisition	Integrated Evaluation (Total point)
		Facility Maintenance	Operation Technology	Construction	O&M	Amount	Property		
1) Stabilization Pond	B 2	B 2	B 2	B 2	A 3	A 3	B 2	E very huge	**Out of Evaluation**
2) Aerated Lagoon	B 2	C 1	A 3	B 2	B 2	B 2	B 2	D 0	**14**
3) Oxidation Ditch	B 2	C 1	C 1	D 0	C 1	C 1	B 2	C 1	**9**
4) Conventional Activated Sludge	D 0	C 1	B 2	C 1	C 1	C 1	C 2	A 3	**11**
5) Rotating Biological Contactor	C 1	C 1	B 2	C 1	C 1	C 1	D 0	B 2	**9**

Note : 1) A : Excellent : 3 point
B : Good : 2 point
C : Moderate : 1point
D : Inferior : 0 point
E : Much inferior : out of evaluation
2) Figures in the colum : point of evaluation

Table F.6.4 Main Features of Wastewater Collection System for 9 Zones

THBNDT Zone

Sewer Type	Diameter (mm)	Length (m)
Interceptor	500 - 2,500	34,750
Conveyance	2,500	6,400
Total		41,150

NLTN Zone

Sewer Type	Diameter (mm)	Length (m)
Interceptor	500 - 2,500	32,033
Conveyance	2,500	9,358
Total		41,391

THLG Zone

Sewer Type	Diameter (mm)	Length (m)
Interceptor	800 - 2,000	16,305
Conveyance	2,500	6,564
Total		22,869

TLBC Zone

Sewer Type	Diameter (mm)	Length (m)
Interceptor	700 - 1,600	9,356
Conveyance	1,600	635
Total		9,991

SW Zone

Sewer Type	Diameter (mm)	Length (m)
Secondary/Tertiary	150 - 500	63,120
Main	600 - 1,100	143,066
Conveyance	1,100	2,899
Total		209,085

SS Zone

Sewer Type	Diameter (mm)	Length (m)
Secondary/Tertiary	150 - 500	71,424
Main	600 - 1,100	165,168
Total		236,592

SN-I Zone

Sewer Type	Diameter (mm)	Length (m)
Secondary/Tertiary	150 - 500	101,472
Main	600 - 1,200	234,654
Total		336,126

SN-II Zone

Sewer Type	Diameter (mm)	Length (m)
Secondary/Tertiary	150 - 500	55,296
Main	600 - 1,000	127,872
Total		183,168

SE Zone

Sewer Type	Diameter (mm)	Length (m)
Secondary/Tertiary	150 - 500	81,120
Main	600 - 1,300	187,590
Total		268,710

Table F.8.1 Break-down of Project Cost

(unit : Billion VND)

No	Zone	Construction Cost (DC)	Land Acquisition Cost (LC)	Engineering Cost DC x 0.07	Administration Cost (DC+LC) x 0.015	Physical Contingency DC x 0.1	Total
1	THBNDT	3,156.0	14.6	220.9	95.2	315.6	3,802.3
2	NLTN	3,226.0	13.7	225.8	97.2	322.6	3,885.3
3	THLG	1,887.1	8.1	132.1	56.9	188.7	2,272.9
4	TLBC	1,051.3	2.2	73.6	31.6	105.1	1,263.8
5	SW	1,939.4	10.9	135.8	58.5	193.9	2,338.5
6	SS	1,932.3	2.2	135.3	58.0	193.2	2,321.0
7	SN-I	2,708.5	2.0	189.6	81.3	270.9	3,252.3
8	SN-II	1,445.5	1.4	101.2	43.4	144.6	1,736.1
9	SE	2,570.0	2.4	179.9	77.2	257.0	3,086.5
Total		19,916.1	57.5	1,394.2	599.3	1,991.6	23,958.7

Note: Engineering cost is assumed at 7% of Construction cost.
Administration cost is assumed at 1.5% of Construction and Land Acquistion costs.
Physical contingency is assumed at 10% of Construction cost.
Cost estimation was done based on February 1999 prices.
Exchange rates are as follows.
1US$ = Y 120, 1US$ = VND 13,332

Table F.8.2 DISBURSEMENT SCHEDULE FOR SEWERAGE DEVELOPMENT

(unit: Billion VND)

Sewerage Zone	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
THBNDT	125	726	726	726	726	726																3,755
NLTN				127	742	742	742	742	742													3,837
THLG						74	434	434	434	434	434											2,245
TLBC						39	242	242	242	242	242											1,248
SW											79	446	446	446	446	446						2,309
SS																70	444	444	444	444	444	2,292
SN-I																97	623	623	623	623	623	3,212
SN-II																52	333	333	333	333	333	1,715
SE											92	591	591	591	591	591						3,048
TOTAL	125	726	726	853	1,468	1,581	1,418	1,418	1,418	676	847	1,037	1,037	1,037	1,037	1,256	1,400	1,400	1,400	1,400	1,400	23,659

Table F.8.2 DISBURSEMENT SCHEDULE FOR SEWERAGE DEVELOPMENT

(unit: Billion VND)

Sewerage Zone	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
THBNDT	125	726	726	726	726	726																3,755
NLTN				127	742	742	742	742	742													3,837
THLG						74	434	434	434	434	434											2,245
TLBC						39	242	242	242	242	242											1,248
SW											79	446	446	446	446	446						2,309
SS																70	444	444	444	444	444	2,292
SN-I																97	623	623	623	623	623	3,212
SN-II																52	333	333	333	333	333	1,715
SE											92	591	591	591	591	591						3,048
TOTAL	125	726	726	853	1,468	1,581	1,418	1,418	1,418	676	847	1,037	1,037	1,037	1,037	1,256	1,400	1,400	1,400	1,400	1,400	23,659

Table F.10.1(1/4) Service Area and Population of Project Area by Sub-Zone/Distric/Ward

Sub Zone	District	Ward	Area (ha)	1997	2010	2020
1	Q. 1	P. Ben Nghe	153.0	19,933	19,871	19,823
Total of Sub Zone 1			153.0	19,933	19,871	19,823
2	Q. 1	P. Ben Nghe	62.8	8,181	8,156	8,136
	Q. 1	P. Ben Thanh	93.0	26,396	26,244	26,127
	Q. 1	P. Pham Ngu Lao	16.4	9,350	9,264	9,199
	Q. 3	P. 5	1.3	1,044	1,024	1,008
Total of Sub Zone 2			173.5	44,971	44,688	44,470
3	Q. 1	P. Pham Ngu Lao	22.0	12,543	12,428	12,340
Total of Sub Zone 3			22.0	12,543	12,428	12,340
4	Q. 1	P. Cau Ong Lanh	20.6	20,959	20,115	19,488
	Q. 1	P. Co Giang	7.9	6,810	6,474	6,228
	Q. 1	P. Nguyen Thai Binh	44.4	23,744	21,742	20,318
Total of Sub Zone 4			72.9	51,513	48,331	46,034
5	Q. 1	P. Nguyen Cu Trinh	54.8	21,184	21,081	21,003
	Q. 1	P. Pham Ngu Lao	11.8	6,728	6,666	6,618
	Q. 3	P. 2	1.8	1,690	1,617	1,562
	Q. 3	P. 5	3.4	2,731	2,677	2,637
Total of Sub Zone 5			71.8	32,333	32,041	31,820
6	Q. 1	P. Cau Kho	21.6	16,446	15,227	14,351
	Q. 1	P. Co Giang	25.4	21,895	20,817	20,023
Total of Sub Zone 6			47.0	38,341	36,044	34,374
7	Q. 1	P. Nguyen Cu Trinh	21.7	8,388	8,348	8,317
	Q. 3	P. 1	15.3	19,760	19,066	18,548
	Q. 3	P. 2	13.6	12,768	12,214	11,805
	Q. 3	P. 3	15.6	14,619	14,125	13,757
	Q. 3	P. 5	0.8	642	630	620
	Q. 5	P. 2	25.6	19,618	18,924	18,409
	Q. 5	P. 3	15.9	8,140	7,469	6,991
	Q. 5	P. 4	33.9	13,817	13,149	12,659
	Q. 10	P. 1	21.0	16,481	16,432	16,395
	Q. 10	P. 2	10.4	11,429	11,384	11,348
	Q. 10	P. 9	10.0	11,747	11,708	11,678
	Q. 10	P. 10	18.0	14,707	14,633	14,577
	Q. 10	P. 11	11.6	8,095	8,072	8,055
	Q. 10	P. 12	18.7	3,036	3,033	3,030
Total of Sub Zone 7			232.1	163,247	159,187	156,189
8	Q. 1	P. Cau Kho	9.6	7,309	6,767	6,378
	Q. 5	P. 1	35.3	24,057	21,658	19,977
Total of Sub Zone 8			44.9	31,366	28,425	26,355
9	Q. 5	P. 2	2.8	2,145	2,070	2,013
	Q. 5	P. 3	2.0	1,024	940	879
	Q. 5	P. 4	3.5	1,426	1,358	1,307
	Q. 5	P. 7	10.2	7,613	7,277	7,029
	Q. 5	P. 8	5.9	3,088	2,914	2,787
	Q. 5	P. 9	10.9	5,048	4,897	4,783
	Q. 10	P. 2	5.1	5,605	5,582	5,565
Total of Sub Zone 9			40.4	25,949	25,038	24,363
10	Q. 5	P. 1	3.6	2,453	2,209	2,037
	Q. 5	P. 2	0.1	77	74	72
	Q. 5	P. 5	19.6	19,052	17,221	15,934
	Q. 5	P. 6	0.1	68	59	53
	Q. 5	P. 7	0.3	224	214	207
Total of Sub Zone 10			23.7	21,874	19,777	18,303

Table F.10.1(2/4) Service Area and Population of Project Area by Sub-Zone/Distric/Ward

Sub Zone	District	Ward	Area (ha)	1997	2010	2020
11	Q. 5	P. 7	9.2	6,866	6,564	6,339
	Q. 5	P. 8	12.5	6,543	6,175	5,905
	Q. 5	P. 9	17.0	7,874	7,637	7,461
	Q. 10	P. 2	4.6	5,055	5,035	5,020
	Q. 10	P. 3	10.5	11,898	11,810	11,742
	Q. 10	P. 4	16.6	16,049	15,977	15,922
	Q. 10	P. 5	3.3	3,095	3,080	3,069
	Q. 10	P. 8	0.7	696	693	690
	Q. 10	P. 9	4.1	4,816	4,800	4,788
Total of Sub Zone 10			78.5	62,892	61,771	60,936
12	Q. 5	P. 5	1.1	1,069	967	894
	Q. 5	P. 6	14.1	9,610	8,343	7,483
Total of Sub Zone 12			15.2	10,679	9,310	8,377
13	Q. 5	P. 6	6.3	4,294	3,728	3,344
	Q. 5	P. 7	4.9	3,657	3,496	3,377
	Q. 5	P. 8	5.9	3,088	2,914	2,787
	Q. 5	P. 9	9.9	4,585	4,448	4,345
	Q. 5	P. 10	22.3	15,357	13,535	12,282
	Q. 5	P. 11	30.1	18,047	17,298	16,743
	Q. 5	P. 12	34.7	6,759	6,283	5,940
	Q. 5	P. 13	10.0	7,276	6,030	5,218
	Q. 5	P. 14	7.8	5,358	5,185	5,055
	Q. 10	P. 5	12.4	11,631	11,575	11,531
	Q. 10	P. 6	22.0	10,346	10,294	10,254
	Q. 10	P. 7	10.8	14,094	14,001	13,930
	Q. 10	P. 8	14.0	13,915	13,853	13,805
	Q. 10	P. 9	6.0	7,049	7,025	7,006
	Q. 10	P. 12	19.1	3,101	3,097	3,095
	Q. 10	P. 14	43.6	7,693	7,683	7,675
	Q. 11	P. 4	3.2	2,458	2,422	2,394
	Q. 11	P. 6	0.9	815	802	793
	Q. 11	P. 7	13.2	13,752	13,542	13,384
Total of Sub Zone 13			277.1	153,275	147,211	142,958
14	Q. 5	P. 12	5.2	1,013	942	890
	Q. 5	P. 13	14.3	10,405	8,622	7,462
	Q. 5	P. 14	18.8	12,914	12,497	12,185
	Q. 5	P. 15	17.0	14,047	13,295	12,745
	Q. 6	P. 1	9.6	5,323	5,180	5,073
	Q. 6	P. 2	4.2	3,635	3,562	3,508
	Q. 10	P. 14	26.4	4,658	4,652	4,647
	Q. 11	P. 4	12.8	9,840	9,690	9,575
	Q. 11	P. 6	15.0	13,575	13,375	13,223
	Q. 11	P. 7	3.3	3,438	3,386	3,346
	Q. 11	P. 12	11.0	9,658	9,477	9,340
	Q. 11	P. 13	13.6	12,460	12,270	12,126
	Q. 11	P. 15	45.8	9,573	9,866	9,473
	Q. Tan Binh	P. 8	25.1	13,068	13,610	14,042
	Q. Tan Binh	P. 9	13.4	7,393	7,615	7,791
	Q. Tan Binh	P. 10	3.4	1,401	1,443	1,475
Total of Sub Zone 14			238.9	132,401	129,482	126,901

Table F.10.1(3/4) Service Area and Population of Project Area by Sub-Zone/Distric/Ward

Sub Zone	District	Ward	Area (ha)	1997	2010	2020
15	Q. 5	P. 14	3.1	2,130	2,061	2,009
	Q. 5	P. 15	3.2	2,644	2,503	2,399
	Q. 6	P. 1	17.6	9,759	9,497	9,301
	Q. 6	P. 2	10.7	9,260	9,075	8,936
	Q. 6	P. 6	3.8	2,788	2,984	3,145
	Q. 11	P. 4	1.0	768	757	748
	Q. 11	P. 6	0.4	362	357	353
	Q. 11	P. 11	5.6	4,247	4,201	4,166
	Q. 11	P. 12	2.3	2,020	1,982	1,953
	Q. 11	P. 12	0.5	439	430	425
	Q. 11	P. 13	2.9	2,657	2,616	2,586
	Q. 11	P. 13	0.1	91	91	89
	Q. 11	P. 15	36.9	7,713	7,948	7,633
	Q. 11	P. 16	12.6	7,190	7,124	7,074
	Q. Tan Binh	P. 8	1.7	885	922	951
	Q. Tan Binh	P. 9	36.5	20,137	20,743	21,221
	Q. Tan Binh	P. 10	37.6	15,488	15,959	16,319
Total of Sub Zone 15			176.5	88,578	89,250	89,308
16	Q. 6	P. 1	4.6	2,551	2,483	2,431
	Q. 6	P. 2	2.5	2,163	2,121	2,088
	Q. 6	P. 3	27.6	14,654	13,891	13,330
	Q. 6	P. 4	23.8	15,377	15,856	16,235
	Q. 6	P. 5	10.3	14,187	13,416	12,852
	Q. 6	P. 6	10.2	7,483	8,011	8,442
	Q. 6	P. 7	27.0	10,167	9,654	9,278
	Q. 6	P. 8	5.1	3,282	3,363	3,427
Total of Sub Zone 16			111.1	69,864	68,795	68,083
Khanh Hoi	Q.4	P.1	24.7	9,200	6,909	5,542
	Q.4	P.2	15.6	13,203	13,018	12,877
	Q.4	P.3	22.8	12,717	12,262	11,923
	Q.4	P.4	27.1	17,255	17,103	16,988
	Q.4	P.5	25.2	11,408	10,973	10,649
	Q.4	P.6	16.1	16,860	16,568	16,347
	Q.4	P.8	13.9	19,281	19,425	19,536
	Q.4	P.9	11.6	15,119	14,827	14,606
	Q.4	P.10	11.6	14,009	14,167	14,289
	Q.4	P.12	33.2	11,829	11,328	10,958
	Q.4	P.13	32.1	13,884	13,808	13,750
	Q.4	P.14	16.4	17,162	17,355	17,505
	Q.4	P.15	18.4	14,171	13,645	13,253
	Q.4	P.16	31.2	19,013	18,786	18,613
	Q.4	P.18	50.3	14,106	13,054	12,298
Total of Sub Zone Khanh Hoi			350.2	219,217	213,228	209,134
Ong Kieu	Q.4	P.1	3.9	1,434	1,077	864
Total of Sub Zone Ong Kieu			3.9	1,434	1,077	864
Hung Phu	Q.8	P.8	23.2	15,096	13,847	12,956
	Q.8	P.9	34.8	27,203	26,058	25,210
	Q.8	P.10	18.8	24,921	19,834	16,640
Total of Sub Zone Hung Phu			76.7	67,220	59,739	54,806
Tung Thien Vuong	Q.8	P.11	22.0	14,852	8,128	5,112
	Q.8	P.12	26.9	24,176	23,825	23,558
	Q.8	P.13	33.1	12,560	12,342	12,177
Total of Sub Zone Tung Thien Vuong			82.0	51,588	44,295	40,847

Table F.10.1(4/4) Service Area and Population of Project Area by Sub-Zone/Distric/Ward

Sub Zone	District	Ward	Area (ha)	1997	2010	2020
Binh Dong	Q.8	P.14	44.8	19,726	18,418	17,470
	Q.8	P.14	3.1	1,347	1,258	1,193
	Q.8	P.14	0.7	296	277	262
Total of Sub Zone Binh Dong			48.6	21,369	19,952	18,926
Rach Ong	Q.8	P.1	41.7	21,444	19,393	17,950
	Q.8	P.2	45.4	24,660	25,737	26,599
	Q.8	P.3	45.9	22,511	22,350	22,229
Total of Sub Zone Rach Ong			133.0	68,615	67,480	66,778
Pham The Hien	Q.8	P.4	131.0	29,367	31,184	32,657
	Q.8	P.5	64.8	10,994	11,612	12,111
Total of Sub Zone Pham The Hien			195.8	40,361	42,796	44,768
Binh Dang	Q.8	P.5	88.7	15,050	15,897	16,581
	Q.8	P.6	119.3	24,090	25,665	26,944
Total of Sub Zone Binh Dang			208.0	39,140	41,562	43,525
Grand Total of Project Area			2,876.8	1,468,703	1,421,778	1,390,282

Table F.11.1 Preliminary Design of Interceptor and Conveyance

Alternative A

Sewerage Development Zone	Pipe No.		Catchment Area (ha)	Link to Pipe No.	Interceptor Length (m)	Accumulated Area (ha)	Diameter (mm)	Slope (1/1000)	Ground Elevation (m)	Earth Covering (m)	Invert Level (m)	Ground Elevation (m)	Earth Covering (m)	Invert Level (m)	Pump St. Head (m)	Average Depth (m)	Unit Price (1000VND)	Construction Cost (MVND)
1) THBNDT	Main Interceptor	1	132.4	2	870	132.4	700	1.7	1.8	3.7	-2.6	2.1	5.5	-4.1		5	3,336	2,902
	(East Side)	2	141.2	3	1,130	273.6	1,000	1.4	2.1	5.2	-4.1	2.0	6.7	-5.7		7	5,324	6,016
	- Ton Duc Thang	3	22.0	5	840	295.6	1,000	1.4	2.0	6.7	-5.7	1.8	7.6	-6.8		8	6,640	5,578
	- Ham Nghi	5	71.8	7	1,070	367.4	1,100	1.3	1.8	7.5	-6.8	1.9	9.0	-8.2		10	48,174	51,546
	- Tran Hung Dao	7	232.1	9	1,070	599.5	1,300	1.2	1.9	8.8	-8.2	1.8	10.0	-9.5		11	51,152	54,733
	streets	9	35.9	C1	500	635.4	1,500	1.2	1.8	9.8	-9.5	1.8	10.4	-10.1		12	55,167	27,584
	Sub-Total		635.4		5,480													148,358
	2nd Interceptor	4	72.9	6	1,350	72.9	600	1.9	1.8	1.2	0.0	2.1	4.1	-2.6		3	1,470	1,985
	(East Side)	6	47.0	8	1,020	119.9	700	1.7	2.1	4.0	-2.6	2.1	5.7	-4.3		6	1,860	1,897
	- Ben Chuong Duong	8	44.9	10	1,340	164.8	800	1.5	1.8	5.3	-4.3	1.8	7.3	-6.3		7	5,103	6,838
	street	10	23.7	C2	520	188.5	800	1.5	1.8	7.3	-6.3	2.0	8.3	-7.1		8	5,103	2,654
	Sub-Total		188.5		4,230													13,373
	Total		823.9		9,710													161,732
	Main Interceptor	16	111.0	15	1,950	111.0	700	1.7	2.0	1.2	0.1	2.0	4.5	-3.2		4	1,860	3,627
	(West Side)	15	168.6	14	400	279.6	1,000	1.4	2.0	4.2	-3.2	2.0	4.8	-3.8		6	4,294	1,718
	- Tran Van Kieu	14	214.5	13	550	494.1	1,200	1.2	2.0	4.6	-3.8	2.0	5.2	-4.4		6	5,767	3,172
	- Ben Ham Tu	13	264.6	11+12	1,340	758.7	1,500	1.2	2.0	4.9	-4.4	2.0	6.5	-6.0		8	7,597	10,180
	streets	11+12	104.3	C2	750	863.0	1,500	1.2	2.0	6.5	-6.0	2.0	7.4	-6.9		9	55,167	41,375
	Sub-Total		863.0		4,990													60,072
	Conveyance	C1	0.0	C2	500	635.4	1,500	1.2	1.8	7.2	-6.9	2.0	8.0	-7.5		9		0
		C2	0.0	C3	300	1,686.9	2,000	1.2	2.0	7.5	-7.5	1.8	7.7	-7.9		10		0
		C3	0.0	C4	200	1,686.9	2,000	1.2	1.8	7.7	-7.9	1.8	7.9	-8.1		10		0
		C4	0.0	C5	1,000	1,686.9	2,000	1.2	1.8	1.2	-1.4	1.8	2.4	-2.6	6.7	4		0
		C5	0.0	C6	300	1,686.9	2,000	1.2	1.8	2.4	-2.6	1.8	2.8	-3.0		5		0
		C6	0.0	C7	700	1,686.9	2,000	1.2	1.8	2.8	-3.0	1.8	3.6	-3.8		6		0
		C7	0.0	C8	50	1,686.9	2,000	1.2	1.8	3.6	-3.8	1.8	3.7	-3.9		6		0
		C8	0.0	C9	350	1,686.9	2,000	1.2	1.8	3.7	-3.9	1.8	4.1	-4.3		6		0
		C9	0.0	C10	200	1,686.9	2,000	1.2	1.8	4.1	-4.3	1.8	4.4	-4.6		7		0
		C10	0.0	C11	200	1,686.9	2,000	1.2	1.8	4.4	-4.6	1.8	4.6	-4.8		7		0
		C11	0.0	C12	1,100	1,686.9	2,000	1.2	1.8	4.6	-4.8	1.8	5.9	-6.1		8		0
		C12	0.0	C13	100	1,686.9	2,000	1.2	1.8	5.9	-6.1	1.8	6.0	-6.2		8		0
		C13	0.0	TP	1,400	1,686.9	2,000	1.2	1.8	6.0	-6.2	2.6	8.5	-7.9		10		0
	Sub-Total		0.0		6,400													0
Total			1,686.9		21,100													221,803

Table F.11.2 Preliminary Design of Interceptor and Conveyance

Alternative B

Sewerage Development Zone	Pipe No.		Catchment Area (ha)	Link to Pipe No.	Interceptor Length (m)	Accumulated Area (ha)	Diameter (mm)	Slope (1/1000)	Ground Elevation (m)	Earth Covering (m)	Invert Level (m)	Ground Elevation (m)	Earth Covering (m)	Invert Level (m)	Pump St. Head (m)	Average Depth (m)	Unit Price (1000VND)	Construction Cost (MVND)
1) THBNDT	Main Interceptor	1	132.4	2+3+4	870	132.4	700	1.7	1.8	3.7	-2.6	2.1	5.5	-4.1		5	3,336	2,902
	(East Side)	2+3+4	236.1	5+6	1,655	368.5	1,100	1.3	2.1	5.1	-4.1	1.8	6.9	-6.2		7	5,545	9,177
	- Ton Duc Thang	5+6	118.8	7+8	1,020	487.3	1,200	1.3	1.8	6.8	-6.2	1.8	8.2	-7.6		9	52,059	53,100
	- Ben Chuong Duong	7+8	277.0	9+10	1,340	764.3	1,500	1.2	1.8	7.9	-7.6	1.8	9.5	-9.2		10	55,167	73,924
	streets	9+10	59.6	C2	520	823.9	1,500	1.2	1.8	9.5	-9.2	2.0	10.3	-9.8		12	55,167	28,687
	Sub-Total		823.9		5,405													167,790
	Main Interceptor	16	111.0	15	1,950	111.0	700	1.7	2.0	1.2	0.1	2.0	4.5	-3.2		4	1,860	3,627
	(West Side)	15	168.6	14	400	279.6	1,000	1.4	2.0	4.2	-3.2	2.0	4.8	-3.8		6	4,294	1,718
	- Tran Van Kieu	14	214.5	13	550	494.1	1,200	1.2	2.0	4.6	-3.8	2.0	5.2	-4.4		6	5,767	3,172
	- Ben Ham Tu	13	264.6	11+12	1,340	758.7	1,500	1.2	2.0	4.9	-4.4	2.0	6.5	-6.0		8	7,597	10,180
	streets	11+12	104.3	C2	750	863.0	1,500	1.2	2.0	6.5	-6.0	2.0	7.4	-6.9		9	55,167	41,375
	Sub-Total		863.0		4,990													60,072
	Conveyance	C2	0.0	C3	300	1,686.9	2,000	1.2	2.0	9.8	-9.8	1.8	9.9	-10.1		12		0
		C3	0.0	C4	200	1,686.9	2,000	1.2	1.8	9.9	-10.1	1.8	10.2	-10.4		12		0
		C4	0.0	C5	1,000	1,686.9	2,000	1.2	1.8	1.2	-1.4	1.8	2.4	-2.6	9	4		0
		C5	0.0	C6	300	1,686.9	2,000	1.2	1.8	2.4	-2.6	1.8	2.7	-2.9		5		0
		C6	0.0	C7	700	1,686.9	2,000	1.2	1.8	2.7	-2.9	1.8	3.6	-3.8		6		0
		C7	0.0	C8	50	1,686.9	2,000	1.2	1.8	3.6	-3.8	1.8	3.6	-3.8		6		0
		C8	0.0	C9	350	1,686.9	2,000	1.2	1.8	3.6	-3.8	1.8	4.1	-4.3		6		0
		C9	0.0	C10	200	1,686.9	2,000	1.2	1.8	4.1	-4.3	1.8	4.3	-4.5		7		0
		C10	0.0	C11	200	1,686.9	2,000	1.2	1.8	4.3	-4.5	1.8	4.5	-4.7		7		0
		C11	0.0	C12	1,100	1,686.9	2,000	1.2	1.8	4.5	-4.7	1.8	5.9	-6.1		8		0
		C12	0.0	C13	100	1,686.9	2,000	1.2	1.8	5.9	-6.1	1.8	6.0	-6.2		8		0
		C13	0.0	TP	1,400	1,686.9	2,000	1.2	1.8	6.0	-6.2	2.6	8.5	-7.9		10		0
	Sub-Total		0.0		5,900													0
Total			1,686.9		16,295													227,862

Table F.11.3 Preliminary Design of Interceptor and Conveyance

Alternative C

Sewerage Development Zone	Pipe No.		Catchment Area (ha)	Link to Pipe No.	Interceptor Length (m)	Accumulated Area (ha)	Diameter (mm)	Slope (1/1000)	Ground Elevation (m)	Earth Covering (m)	Invert Level (m)	Ground Elevation (m)	Earth Covering (m)	Invert Level (m)	Pump St. Head (m)	Average Depth (m)	Unit Price (1000VND)	Construction Cost (MVND)
1) THBNDT	Main Interceptor	1	132.4	2	870	132.4	700	1.7	1.8	3.7	-2.6	1.8	5.2	-4.1		5	3,336	2,902
	(East Side)	2	141.2	3+4	1,130	273.6	1,000	1.4	1.8	4.9	-4.1	2.1	6.8	-5.7		7	5,324	6,016
	- Ton Duc Thang	3+4	94.9	5+6	840	368.5	1,100	1.3	2.1	6.7	-5.7	1.8	7.5	-6.8		8	6,640	5,578
	- Ham Nghi	5+6	118.8	7+8	1,070	487.3	1,200	1.3	1.8	7.4	-6.8	1.8	8.7	-8.1		9	52,059	55,703
	- Tran Hung Dao	7+8	277.0	9+10	1,070	764.3	1,500	1.2	1.8	8.4	-8.1	1.8	9.7	-9.4		11	55,167	59,029
	streets	9+10	59.6	C1	500	823.9	1,500	1.2	1.8	9.7	-9.4	1.8	10.3	-10.0		12	55,167	27,584
	Sub-Total		823.9		5,480													156,811
	Main Interceptor	16	111.0	15	1,950	111.0	700	1.7	2.0	1.2	0.1	2.0	4.5	-3.2		4	1,860	3,627
	(West Side)	15	168.6	14	400	279.6	1,000	1.4	2.0	4.2	-3.2	2.0	4.8	-3.8		6	4,294	1,718
	- Tran Van Kieu	14	214.5	13	550	494.1	1,200	1.2	2.0	4.6	-3.8	2.0	5.2	-4.4		6	5,767	3,172
	- Ben Ham Tu	13	264.6	11+12	1,340	758.7	1,500	1.2	2.0	4.9	-4.4	2.0	6.5	-6.0		8	7,597	10,180
	streets	11+12	104.3	C2	750	863.0	1,500	1.2	2.0	6.5	-6.0	2.0	7.4	-6.9		9	55,167	41,375
	Sub-Total		863.0		4,990													60,072
	Conveyance	C1	0.0	C2	500	823.9	1,500	1.2	1.8	10.3	-10.0	2.0	11.1	-10.6		13		0
		C2	0.0	C3	300	1,686.9	2,000	1.2	2.0	10.6	-10.6	1.8	10.8	-11.0		13		0
		C3	0.0	C4	200	1,686.9	2,000	1.2	1.8	10.8	-11.0	1.8	11.0	-11.2		13		0
		C4	0.0	C5	1,000	1,686.9	2,000	1.2	1.8	1.2	-1.4	1.8	2.4	-2.6	9.8	4		0
		C5	0.0	C6	300	1,686.9	2,000	1.2	1.8	2.4	-2.6	1.8	2.8	-3.0		5		0
		C6	0.0	C7	700	1,686.9	2,000	1.2	1.8	2.8	-3.0	1.8	3.6	-3.8		6		0
		C7	0.0	C8	50	1,686.9	2,000	1.2	1.8	3.6	-3.8	1.8	3.7	-3.9		6		0
		C8	0.0	C9	350	1,686.9	2,000	1.2	1.8	3.7	-3.9	1.8	4.1	-4.3		6		0
		C9	0.0	C10	200	1,686.9	2,000	1.2	1.8	4.1	-4.3	1.8	4.3	-4.5		7		0
		C10	0.0	C11	200	1,686.9	2,000	1.2	1.8	4.3	-4.5	1.8	4.6	-4.8		7		0
		C11	0.0	C12	1,100	1,686.9	2,000	1.2	1.8	4.6	-4.8	1.8	5.9	-6.1		8		0
		C12	0.0	C13	100	1,686.9	2,000	1.2	1.8	5.9	-6.1	1.8	6.0	-6.2		8		0
		C13	0.0	TP	1,400	1,686.9	2,000	1.2	1.8	6.0	-6.2	2.6	8.5	-7.9		10		0
	Sub-Total		0.0		6,400													0
Sub-Total			1,686.9		16,870													216,885
2nd Interceptor																		11,430
Grand Total																		228,313

Table F.11.4 Preliminary Design of Interceptor for Island and Southern Areas

Sub-Zone	Pipe No.	Catchment Area (ha)	Link to Pipe No.	Interceptor Length (m)	Accumulated Area (ha)	Diameter (mm)	Slope (1/1000)	Ground Elevation (m)	Earth Covering (m)	Invert Level (m)	Ground Elevation (m)	Earth Covering (m)	Invert Level (m)	Average Depth (m)	Unit Construction Cost (1000VND)	Construction Method	Construction Cost (Million VND)
Khanh Hoi	K1	55.5	K2	207	55.5	500	2.0	2.6	1.2	0.9	2.0	1.0	0.5	2	870	OP	180.09
	K2	115.4	K4	1,652	170.9	800	1.5	2.0	0.7	0.5	1.4	2.6	-2.0	3	1,590	OP	2,626.68
	K3	7.0	K4	514	7.0	400	2.1	1.3	1.2	-0.3	1.4	2.4	-1.4	2	760	OP	390.64
	K4	12.6	K5	600	190.5	800	1.5	1.4	2.6	-2.0	1.5	3.6	-2.9	4	1,920	OP	1,152.00
	K8	32.7	K7	960	32.7	400	2.1	1.7	1.2	0.1	1.5	3.1	-1.9	3	1,270	OP	1,219.20
	K7	46.6	K6	582	79.3	600	1.9	1.5	2.9	-1.9	1.3	3.7	-3.0	4	1,400	OP	814.80
	K6	67.4	K5	1,259	146.7	800	1.5	1.3	3.5	-3.0	1.5	5.6	-4.9	6	4,153	OP	5,228.63
	K5	12.0	KC	560	349.2	1,100	1.3	1.5	5.3	-4.9	1.3	5.8	-5.6	7	5,545	OP	3,105.20
	KC	0.0	R1	179	349.2	900	Siphone 2 line	-7.0	2.0	-10.0	-7.0	2.0	-10.0	Te Canal	132,090	ST	23,644.11
Sub-Total		349.2		6,513													38,361.35
Hung Phu	H1	23.3	H2	845	23.3	400	2.1	1.5	1.2	-0.2	1.5	3.0	-1.9	3	1,270	OP	1,073.15
	H2	9.3	HC	797	32.6	400	2.1	1.5	3.0	-1.9	1.4	4.6	-3.6	4	1,600	OP	1,275.20
	H3	10.0	H5	733	10.0	400	2.1	1.4	1.2	-0.2	1.5	2.8	-1.7	2	760	OP	557.08
	H4	15.6	H5	823	15.6	400	2.1	1.4	1.2	-0.2	1.5	3.0	-1.9	3	1,270	OP	1,045.21
	H5	9.6	HC	387	35.2	400	2.1	1.5	3.0	-1.9	1.4	3.7	-2.7	4	1,600	OP	619.20
	H6	13.2	HC	798	13.2	400	2.1	1.7	1.2	0.1	1.4	2.6	-1.6	2	760	OP	606.48
	HC	0.0	P2	150	81.0	500	Siphone 2 line	-7.0	2.0	-9.6	-7.0	2.0	-9.6	Doi Canal	55,167	PJ	8,826.72
Sub-Total		81.0		4,543													14,003.04
Binh Dong	BDO1	24.7	BDOC	1,077	24.7	400	2.1	1.4	1.2	-0.2	1.7	3.8	-2.4	3	1,270	OP	1,367.79
	BDO2	20.5	BDOC	1,424	20.5	400	2.1	1.7	1.2	0.0	1.7	4.3	-2.9	3	1,270	OP	1,808.48
	BDOC	0.0	T1	42	45.2	350	Siphone 2 line	-3.0	2.0	-5.4	-3.0	2.0	-5.4	Ngang 1 Canal	3,735	OP	156.87
Sub-Total		45.2		2,543													3,333.14
Tung Thien Vuon	T1	1.0	T3	173	46.2	450	2.0	2.3	5.2	-3.3	1.5	4.7	-3.6	5	3,858	OP	667.43
	T2	15.7	T3	809	15.7	400	2.1	1.6	1.2	-0.0	1.5	2.8	-1.7	2	760	OP	614.84
	T3	5.5	T5	380	67.4	600	1.9	1.5	4.6	-3.6	1.2	5.0	-4.4	5	4,108	OP	1,561.04
	T4	3.6	T5	363	3.6	400	2.1	1.9	1.2	0.3	1.2	1.3	-0.5	2	760	OP	275.88
	T5	1.5	TC	143	72.5	600	1.9	1.2	5.0	-4.4	1.3	5.3	-4.6	6	4,108	OP	587.44
	T6	11.4	T8	1,046	11.4	400	2.1	1.5	1.2	-0.1	1.2	3.1	-2.3	3	1,270	OP	1,328.42
	T7	10.9	T8	825	10.9	400	2.1	1.4	1.2	-0.2	1.2	2.8	-1.9	2	760	OP	627.00
	T8	21.3	TC	981	43.6	450	2.0	1.2	3.1	-2.3	1.3	5.1	-4.3	5	3,188	OP	3,127.43
	TC	0.0	BDA2	150	116.1	500	Siphone 2 line	-8.5	2.0	-11.1	-8.5	2.0	-11.1	Doi Canal	55,167	PJ	8,275.05
Sub-Total		70.9		4,870													17,064.53
Rach Ong	R1	49.0	R2	654	398.2	1,100	1.3	1.9	7.6	-6.8	1.7	8.2	-7.7	9	48,174	PJ	31,505.80
	R2	80.6	RC	519	478.8	1,200	1.2	1.7	8.1	-7.7	2.4	9.4	-8.3	10	52,059	PJ	27,018.62
	RC	0.0	P3	21	478.8	1,200	1.2	2.4	9.4	-8.3	1.8	8.8	-8.3	11	52,059	PJ	1,093.24
Sub-Total		129.6		1,194													59,617.66
Binh Dang	BDA1	133.7	BDA2	1,921	133.7	700	1.7	1.5	1.2	-0.4	2.3	5.2	-3.6	4	1,860	OP	3,573.06
	BDA2	81.8	BDAC	587	331.6	1,000	1.4	2.3	7.5	-6.2	1.4	7.4	-7.0	9	44,289	PJ	25,997.64
	BDAC	0.0	P1	41	331.6	1,000	1.4	1.4	7.4	-7.0	1.5	7.6	-7.1	Xom Cui River	44,289	PJ	1,815.85
Sub-Total		215.5		2,549													31,386.55
Pham The Hien	P1	66.3	P2	809	397.9	1,100	1.3	1.5	7.5	-7.1	1.5	8.5	-8.1	9	48,174	PJ	38,972.77
	P2	138.3	PS	1,074	536.2	1,300	1.2	1.5	8.3	-8.1	1.5	9.6	-9.4	11	54,131	PJ	58,136.69
	P3	0.0	PS	540	478.8	1,200	1.2	1.8	8.8	-8.3	1.5	9.2	-8.9	10	52,059	PJ	28,111.86
Sub-Total		204.6		2,423													125,221.32
Grand Total		1,096.0		24,635													288,987.59