6.6.3 Economic Evaluation of Urban Drainage System Improvement Works

The economic internal rate of return (EIRR) is calculated using the above mentioned annual average benefit and the economic cost, and used as an index of economic feasibility. This EIRR is defined by the following formula:

$$\sum_{t=1}^{t=T} \frac{C_t}{(1+R)^t} = \sum_{t=1}^{t=T} \frac{B_t}{(1+R)^t}$$

where, T = the last year of the project life,
C_t = an annual economic cost flow of the project under study in year t,
B_t = an annual benefit flow derived from the project in year t, and
R = the Economic Internal Rate of Return (EIRR).

The project life is assumed at 50 years after completion of the said drainage system improvement works.
Following table shows a result of economic evaluation for the Urban Drainage System Improvement Works in Ho Chi Minh City including EIRR, B/C and B – C.

Indicator	C Zone	N Zone	W Zone	S Zone	NE Zone	SE Zone	Whole project area
EIRR(%)	13.07	10.63	6.83	8.70	2.19	9.28	10.97
B/C	1.25	1.05	0.66	0.85	0.23	0.91	1.08
B - C (bill. VND)	772.0	95.8	-323.0	-104.7	-796.7	-59.2	501.5

As a whole study area, EIRR, resulted at 10.97 % as shown in the above Table, has cleared the level of 10 % of discount rate applied in this study, so it may say that the Project has a viability to be executed.

From the viewpoint of each Zone, the C and N Zones show a high economic viability reflecting a present economic situation, and the SE Zone also shows a rather high economic viability reflecting future potentiality for development, so the Project may be required to be executed for these Zones.
In this kind of project, the benefit means mainly a mitigation amount of flood and/or inundation damages. Therefore, the said C Zone belonging to the inner cities of the Ho Chi Minh City with high population, in other words the houses-buildings-concentrated area, should be a target to execute the Project with the first priority.

6.7 Prioritization of Drainage Zone

6.7.1 Priority Sequence and Implementation Schedule

Priority sequence of drainage zone will be decided through comparison of the following factors:

(a) Beneficial population
(b) Required project cost per one beneficiary
(c) Flood condition
(d) Damage to Commercial and institutional activity
(e) Required land acquisition area per one beneficiary
(f) Land use grade
(g) Index of economic evaluation: EIRR

The integrated comparison viewing all the factors is shown in the following table:

Priority Comparison

Factor \ Zone		C	N	W	S	NE	SE
(a) Beneficial population	(1997)	I	III	II	III	IV	IV
	(2020)	I	II	III	III	III	III
(b) Required project cost	(1997)	I	IV	II	III	IV	IV
	(2020)	I	II	I	I	II	I
(c) Present flood condition		I	II	II	II	III	II
(d) Damage to commercial and institutional activity		I	II	III	IV	III	IV
(e) Required land acquisition (1997)		I	III	IV	III	IV	III
	(2020)	I	II	II	II	III	II
(f) Land use grade	(1997)	I	II	III	III	III	III
	(2020)	I	II	III	III	II	III
(g) Economic evaluation	(EIRR)	13.03	10.63	6.83	8.70	2.19	10.97
Priority Sequence		First	Second	Second	Third	Third	Second

Note: (a) Beneficial population: I > 20,000 person/flood area (km^2), 10,000 < II < 20,000 5,000 < III < 10,000, IV < 5,000
(b) Required project cost per one beneficiary
I < 10 million VND, 10 < II < 20 million VND, 20 < III < 30 million VND, IV > 30 million VND
(c) Present flood condition: I: Very serious II: serious III: not so serious
(d) Damage to commercial and institutional activity:
I: Large II: Medium III: Small
(e) Required Land acquisition per one beneficiary:
I < 1 m^2 I < II < 5 m^2 5 < III < 10 m^2 IV > 10 m^2
(f) Land use grade: I: High II: Medium III: Low

It can be recognized easily that every factor of C-zone is ranked highest because of its most vulnerable population. So, the drainage zone C is identified as the first priority zone for urban drainage improvement. W, N and SE zones, and S and NE zones are identified as second and third priority sequence zones respectively.

Implementation schedule consisting of three (3) phases is tentatively proposed in conformity with the priority sequences mentioned above. It is shown in the table below:

Tentative Implementation Schedule

Phase	Zone	1996 - 2000	2001 - 2005	2006 - 2010	2011 - 2015	2016 - 2020
I	C-zone		———			
II	N-zone			———	———	
	W-zone		———	———		
	SN-zone			———	———	
III	S-zone			———	———	
	NE-zone				———	———

6.8 Identification of Priority Project for Feasibility Study

The priority drainage zone, C-zone consists of seven catchment areas, C.1 to C.4 and C.a to C.c. As shown in the table below, C.4 catchment is most serious and high priority area. The drainage improvement of C.1, some part of C.2 and C.3 are ongoing by the assistance of the World Bank, Belgium Government and Asian Development Bank respectively. Accordingly, the possible priority project(s) for the feasibility study are selected from C.4 catchment area including remaining catchment area of C.2, C.a and C.b basins. Location of the proposed feasibility study area is shown in Fig. 6.14.

Identification of Priority Project Area

Sub-catchment		Habitual Flood Condition			Flood Vulnerable Population (person/km^2)			Remarks
Name	Area (km^2)	Area (km^2)	Depth (cm)	Duration (hour)	Total	Catch-ment Area	Flood Area	
C.1	31.85	4.81	37.5	7.0	195,629	6,142	40,689	World Bank
C.2	5.14	1.81	33.5	3.0	33,081	6,436	18,327	P. P. P.
C.3	20.22	4.45	35.5	11.2	157,552	7,792	35,373	Belgium/ADB
C.4	41.31	6.19	40.0	6.1	344,210	8,330	55,643	P. P. P.
C.a	4.91	3.73	68.5	4.0	9,839	12,323	29,611	P. P. P.
C.b	1.29	0.22	42.5	3.1	2,880	2,241	12,973	P. P. P.
C.c	1.68	0	0	0	0	0	0	-
Total	106.41	21.20	43.0	6.7	745,188	7,003	35,145	

Note: 1. The figures of flood depth and duration mean the average value.
2. P. P. P. means the possible priority project identified

TABLE 6.1 (1/4) HYDRAULIC DESIGN OF CANAL IMPROVEMENT

(Drainage Zone), Name of Canal, and Their Section	Canal Length L (m)	Design Scale/Discharge Frequency (Year)	Design Scale/Discharge Discharge Qd (m^3/s)	Bed Elevation Start (EL.m)	Bed Elevation End (EL.m)	High Water Level Start (EL.m)	High Water Level End (EL.m)	Design Cross Section Width B1 (m)	B2 (m)	B3 (m)	B4 (m)	B5 (m)	Bank Slope	Height H (m)	Height h (m)	Flow Area A (m^2)	Hydraulic Radius R (m)	Roughness Coefficient n	Canal Bed Slope i (%)	Flow Velocity V (m/s)	Discharge Capacity Qc (m^3/s)
(C - Zone)																					
C. 1: Nhieu Loc - Thi Nghe																					
C. 1. A	550	5	104	-2.36	-2.14	1.74	1.96	34.0	24.0	5.0	22.8	10.5	1.5	4.5	4.1	68.3	2.70	0.025	0.000400	1.55	106
C. 1. B	2,140	5	104	-3.37	-3.26	1.63	1.74	53.0	40.0	6.5	38.8	23.8	1.5	5.4	5.0	156.5	3.74	0.025	0.000050	0.68	107
C. 1. C	1,770	5	116	-3.56	-3.47	1.54	1.63	55.0	42.0	6.5	40.8	25.5	1.5	5.5	5.1	169.1	3.85	0.025	0.000050	0.70	118
C. 1. D	2,320	5	121	-3.67	-3.56	1.43	1.54	56.0	43.0	6.5	41.8	26.5	1.5	5.5	5.1	174.2	3.88	0.025	0.000050	0.70	120
C. 1. E	2,150	5	126	-3.78	-3.67	1.32	1.43	57.0	44.0	6.5	42.8	27.5	1.5	5.5	5.1	179.3	3.91	0.025	0.000050	0.70	126
C. 1. A	550	10	117	-2.76	-2.54	1.74	1.96	34.0	24.0	5.0	22.8	9.3	1.5	4.9	4.5	72.2	2.83	0.025	0.000400	1.60	116
C. 1. B	2,140	10	117	-3.87	-3.76	1.63	1.74	53.0	40.0	6.5	38.8	22.3	1.5	5.9	5.5	168.0	3.99	0.025	0.000050	0.71	120
C. 1. C	1,770	10	129	-3.96	-3.87	1.54	1.63	55.0	42.0	6.5	40.8	24.3	1.5	5.9	5.5	179.0	4.06	0.025	0.000050	0.72	129
C. 1. D	2,320	10	131	-4.07	-3.96	1.43	1.54	56.0	43.0	6.5	41.8	25.3	1.5	5.9	5.5	184.5	4.09	0.025	0.000050	0.72	134
C. 1. E	2,150	10	137	-4.18	-4.07	1.32	1.43	57.0	44.0	6.5	42.8	26.3	1.5	5.9	5.5	190.0	4.12	0.025	0.000050	0.73	138
C. 2: Cau Non - Tau Vat Tat																					
C. 2. A	500	5	53	-2.68	-2.66	1.32	1.35	43.0	30.0	6.5	28.8	16.8	1.5	4.4	4.0	91.2	2.92	0.025	0.000050	0.58	53
C. 2. A'	1,500	5	22	-2.16	-2.08	1.35	1.42	33.0	20.0	6.5	18.8	8.3	1.5	3.9	3.5	47.4	2.27	0.025	0.000050	0.49	23
C. 2. A"	1,500	5	17	-2.16	-2.08	1.35	1.42	30.0	17.0	6.5	15.8	5.3	1.5	3.9	3.5	36.9	2.06	0.025	0.000050	0.46	17
C. 3: Tan Hoa - Lo Gom																					
C. 3. A	2,260	5	90	-1.14	-0.24	2.36	3.26	27.5	17.5	5.0	17.1	13.6	0.5	3.9	3.5	53.7	2.51	0.022	0.000400	1.68	90
C. 3. B	1,970	5	117	-2.43	-1.64	1.57	2.36	29.0	19.0	5.0	18.6	14.6	0.5	4.4	4.0	66.4	2.82	0.022	0.000400	1.82	121
C. 3. C1'	1,840	5	117	-3.52	-3.43	1.48	1.57	52.0	39.0	6.5	38.2	28.2	1	5.4	5.0	166.0	3.92	0.025	0.000050	0.70	117
C. 3. C1	1,000	-	Navigation	-3.87	-3.82	1.43	1.48	60.0	47.0	6.5	46.2	35.6	1	5.7	5.3	216.8	4.28	0.025	0.000050	0.75	162
C. 3. C2	1,500	5	47	-2.6	-2.54	1.43	1.46	51.0	38.0	6.5	36.8	24.8	1.5	4.4	4.0	123.2	3.14	0.025	0.000020	0.38	47
C. 4: Tau Hu - Ben Nghe, Doi - Te						0															
C. 4. A2' (R. Ba Tang)	1,330	5	15	-2.03	-2.00	1.47	1.50	42.9	32.9	5.0	30.4	16.4	2	3.9	3.5	81.9	2.56	0.030	0.000020	0.28	23
C. 4. A2 (R. Ba Tang)	2,000	5	15	-2.07	-2.03	1.43	1.47	Existing Cross Section								#REF!	#REF!	0.030	0.000020	#REF!	#REF!
C. 4. A3 (R. Ba Lon)	2,560	5	18	-2.01	-1.96	1.49	1.54	38.0	28.0	5.0	26.4	12.4	2	3.9	3.5	67.9	2.42	0.030	0.000020	0.27	18
C. 4. A4 (R. Ba Lon)	3,180	5	18	-3.07	-3.01	1.43	1.49	Existing Cross Section								#REF!	#REF!	0.030	0.000020	#REF!	#REF!
C. 4. A1 (Tau Hu)	2,680	-	Navigation	-4.27	-4.25	1.43	1.46	65.6	58.6	3.5	56.2	22.0	3	6.1	5.7	222.9	3.84	0.025	0.000011	0.33	73
C. 4. B (Tau Hu)	2,130	-	Navigation	-4.30	-4.27	1.40	1.43	65.6	58.6	3.5	56.2	22.0	3	6.1	5.7	222.9	3.84	0.025	0.000011	0.33	73
C. 4. C (Tau Hu)	2,190	-	Navigation	-3.12	-3.10	1.38	1.40	57.4	50.4	3.5	48.0	21.0	3	4.9	4.5	155.3	3.14	0.025	0.000011	0.29	44
C. 4. D (Tau Hu)	1,980	-	Navigation	-3.14	-3.12	1.36	1.38	57.4	50.4	3.5	48.0	21.0	3	4.9	4.5	155.3	3.14	0.025	0.000011	0.29	44
C. 4. E (Ben Nghe)	3,170	5	52	-3.18	-3.14	1.32	1.36	62.4	55.4	3.5	53.0	26.0	3	4.9	4.5	177.8	3.26	0.025	0.000011	0.29	52
C. 4. A1 (Doi)	3,470	5	16	-5.37		1.43	1.47	Existing Cross Section								#REF!	#REF!	0.030	0.000011	#REF!	#REF!
C. 4. B (Doi)	2,020	5	117	-5.40	-5.37	1.40	1.43	Existing Cross Section								#REF!	#REF!	0.030	0.000011	#REF!	#REF!
C. 4. C (Doi)	1,400	5	117	-5.41	-5.40	1.39	1.40	Existing Cross Section								#REF!	#REF!	0.030	0.000011	#REF!	#REF!
C. 4. D (Te)	1,970	5	117	-5.43	-5.41	1.37	1.39	Existing Cross Section								#REF!	#REF!	0.030	0.000011	#REF!	#REF!
C. 4. E (Te)	4,250	5	117	-5.48	-5.43	1.32	1.37	Existing Cross Section								#REF!	#REF!	0.030	0.000011	#REF!	#REF!
C. 4. A1 (Doi)	3,470	10	18	-7.07	-7.03	1.43	1.47	Existing Cross Section								#REF!	#REF!	0.030	0.000011	#REF!	#REF!
C. 4. B (Doi)	2,020	10	131	-7.10	-7.07	1.40	1.43	Existing Cross Section								#REF!	#REF!	0.030	0.000011	#REF!	#REF!
C. 4. C (Doi)	1,400	10	131	-7.11	-7.10	1.39	1.40	Existing Cross Section								#REF!	#REF!	0.030	0.000011	#REF!	#REF!
C. 4. D (Te)	1,970	10	131	-7.13	-7.11	1.37	1.39	Existing Cross Section								#REF!	#REF!	0.030	0.000011	#REF!	#REF!
C. 4. E (Te)	4,250	10	131	-7.18	-7.13	1.32	1.37	Existing Cross Section								#REF!	#REF!	0.030	0.000011	#REF!	#REF!
(N - Zone)																					
N. 1: Ben Da Ba Hog																					
N. 1. A	1,070	5	25	-0.03	1.04	2.97	4.04	22.0	14.0	4.0	12.4	0.4	2	3.4	3.0	19.2	1.39	0.030	0.001000	1.31	25
N. 1. B	2,780	5	36	-1.92	-0.53	1.58	2.97	26.0	18.0	4.0	16.4	2.4	2	3.9	3.5	32.9	1.82	0.030	0.000500	1.11	37
N. 1. C	2,040	5	37	-3.02	-2.92	1.48	1.58	40.0	29.0	5.5	27.4	9.4	2	4.9	4.5	82.8	2.80	0.030	0.000045	0.45	37
N. 1. D	3,610	5	37	-3.18	-3.02	1.32	1.48	40.0	29.0	5.5	27.4	9.4	2	4.9	4.5	82.8	2.80	0.030	0.000045	0.45	37

TABLE 6.1 (2/4) HYDRAULIC DESIGN OF CANAL IMPROVEMENT

(Drainage Zone), Name of Canal, and Their Section	Canal Length L (m)	Design Scale/Discharge: Frequency (Year)	Design Scale/Discharge: Discharge Qd (m^3/s)	Bed Elevation: Start (EL.m)	Bed Elevation: End (EL.m)	High Water Level: Start (EL.m)	High Water Level: End (EL.m)	Design Cross Section: Width B1 (m)	B2 (m)	B3 (m)	B4 (m)	B5 (m)	Bank Slope	Height H (m)	Height h (m)	Flow Area A (m^2)	Hydraulic Radius R (m)	Roughness Coefficient n	Canal Bed Slope i (%)	Flow Velocity V (m/s)	Discharge Capacity Qc (m3/s)
N. 2: Tham Luong - Ben Cat																					
N. 2. A	970	5 (daily)	7	3.72	4.69	5.42	6.39	19.5	9.5	5.0	7.9	1.1	2	2.1	1.7	7.7	0.88	0.030	0.001000	0.97	7
N. 2. B	1,680	5 (daily)	11	1.30	2.42	3.30	4.42	21.5	11.5	5.0	9.9	1.9	2	2.4	2.0	11.8	1.09	0.030	0.000667	0.91	11
N. 2. C	4,090	5 (daily)	19	-1.33	0.30	1.67	3.30	25.0	15.0	5.0	13.4	1.4	2	3.4	3.0	22.2	1.50	0.030	0.000400	0.87	19
N. 2. D1	2,490	5 (daily)	24	-2.88	-2.83	1.62	1.67	38.5	28.5	5.0	26.9	8.9	2	4.9	4.5	80.6	2.78	0.030	0.000020	0.29	24
N. 2. A	970	5	69	3.72	4.69	5.42	6.39	19.5	9.5	5.0	7.9	1.1	2	2.1	1.7	7.7	0.88	0.030	0.001000	0.97	7
N. 2. B	1,680	5	78	1.30	2.42	3.30	4.42	21.5	11.5	5.0	9.9	1.9	2	2.4	2.0	11.8	1.09	0.030	0.000667	0.91	11
N. 2. C	4,090	5	78	-1.33	0.30	1.67	3.30	25.0	15.0	5.0	13.4	1.4	2	3.4	3.0	22.2	1.50	0.030	0.000400	0.87	19
N. 2. D1	2,490	5	78	-2.88	-2.83	1.62	1.67	38.5	28.5	5.0	26.9	8.9	2	4.9	4.5	80.6	2.78	0.030	0.000020	0.29	24
N. 2. D2	3,340	5	28	-3.38	-3.32	1.62	1.68	43.0	30.0	6.5	28.4	8.4	2	5.4	5.0	92.0	2.99	0.030	0.000020	0.31	28
N. 2. E	1,560	5	99	-3.91	-3.88	1.59	1.62	71.5	58.5	6.5	56.9	34.9	2	5.9	5.5	252.5	4.24	0.030	0.000020	0.39	99
N. 2. F	2,250	5	99	-3.96	-3.91	1.54	1.59	71.5	58.5	6.5	56.9	34.9	2	5.9	5.5	252.5	4.24	0.030	0.000020	0.39	99
N. 2. G1	4,370	5	99	-4.05	-3.96	1.45	1.54	71.5	58.5	6.5	56.9	34.9	2	5.9	5.5	252.5	4.24	0.030	0.000020	0.39	99
N. 2. G2	3,100	5	16	-2.00	-1.93	1.50	1.57	40.0	27.0	6.5	25.4	11.4	2	3.9	3.5	64.4	2.38	0.030	0.000020	0.27	17
N. 2. G3	2,490	5	24	-2.05	-2.00	1.45	1.50	46.0	33.0	6.5	31.4	17.4	2	3.9	3.5	85.4	2.58	0.030	0.000020	0.28	24
N. 2. H	1,570	5	99	-4.08	-4.05	1.42	1.45	71.5	58.5	6.5	56.9	34.9	2	5.9	5.5	252.5	4.24	0.030	0.000020	0.39	99
N. 2. I	2,500	5	99	-4.13	-4.08	1.37	1.42	71.5	58.5	6.5	56.9	34.9	2	5.9	5.5	252.5	4.24	0.030	0.000020	0.39	99
N. 2. J	2,610	5	99	-4.18	-4.13	1.32	1.37	71.5	58.5	6.5	56.9	34.9	2	5.9	5.5	252.5	4.24	0.030	0.000020	0.39	99
N. 2. E	1,560	10	108	-3.91	-3.88	1.59	1.62	71.5	58.5	6.5	56.9	34.9	2	5.9	5.5	252.5	4.24	0.025	0.000020	0.47	118
N. 2. F	2,250	10	108	-3.96	-3.91	1.54	1.59	71.5	58.5	6.5	56.9	34.9	2	5.9	5.5	252.5	4.24	0.025	0.000020	0.47	118
N. 2. G1	4,370	10	108	-4.05	-3.96	1.45	1.54	71.5	58.5	6.5	56.9	34.9	2	5.9	5.5	252.5	4.24	0.025	0.000020	0.47	118
N. 2. H	1,570	10	108	-4.08	-4.05	1.42	1.45	71.5	58.5	6.5	56.9	34.9	2	5.9	5.5	252.5	4.24	0.025	0.000020	0.47	118
N. 2. I	2,500	10	108	-4.13	-4.08	1.37	1.42	71.5	58.5	6.5	56.9	34.9	2	5.9	5.5	252.5	4.24	0.025	0.000020	0.47	118
N. 2. J	2,610	10	108	-4.18	-4.13	1.32	1.37	71.5	58.5	6.5	56.9	34.9	2	5.9	5.5	252.5	4.24	0.025	0.000020	0.47	118
(W - Zone)																					
W. 1: R. Cua - R. Nuoc Len																					
W. 1. A	2,600	5	65	-2.12	-1.26	1.68	2.54	35.0	25.0	5.0	23.4	8.2	2	4.2	3.8	60.0	2.38	0.030	0.000333	1.09	65
W. 1. B'	1,700	5	65	-3.85	-3.82	1.65	1.68	61.0	48.0	6.5	46.4	24.4	2	5.9	5.5	194.7	3.97	0.030	0.000016	0.33	65
W. 1. B	350	5 (daily)	12	-3.85	-3.85	1.65	1.65	34.0	24.0	5.0	22.4	0.4	2	5.9	5.5	62.7	2.51	0.030	0.000016	0.25	15
W. 1. C1'	3,110	5 (daily)	14	-3.90	-3.85	1.60	1.65	34.0	24.0	5.0	22.4	0.4	2	5.9	5.5	62.7	2.51	0.030	0.000016	0.25	15
W. 1. C1	1,000	5	65	-3.92	-3.90	1.58	1.60	61.0	48.0	6.5	46.4	24.4	2	5.9	5.5	194.7	3.97	0.030	0.000016	0.33	65
W. 1. C2	2,200	5	33	-2.92	-2.88	1.58	1.62	50.0	37.0	6.5	35.4	17.4	2	4.9	4.5	118.8	3.17	0.030	0.000016	0.29	34
W. 1. D1	4,490	5	65	-3.99	-3.92	1.51	1.58	61.0	48.0	6.5	46.4	24.4	2	5.9	5.5	194.7	3.97	0.030	0.000016	0.33	65
W. 1. D2	2,070	5	21	-2.49	-2.46	1.51	1.54	43.0	30.0	6.5	28.4	12.4	2	4.4	4.0	81.6	2.69	0.030	0.000016	0.26	21
W. 1. E1	2,720	5	65	-4.03	-3.99	1.47	1.51	61.0	48.0	6.5	46.4	24.4	2	5.9	5.5	194.7	3.97	0.030	0.000016	0.33	65
W. 1. E2	4,900	5	12	-3.58	-2.05	1.47	1.54	Existing Cross Section								#REF!	#REF!	0.030	0.000016	#REF!	#REF!
W. 1. E3	1,360	5	14	-6.71	-11.26	1.47	1.49	Existing Cross Section								#REF!	#REF!	0.030	0.000016	#REF!	#REF!
W. 1. F	1,180	5	65	-8.46	-6.71	1.45	1.47	Existing Cross Section								#REF!	#REF!	0.030	0.000016	#REF!	#REF!
W. 1. G	1,850	5	65	-6.19	-6.16	1.42	1.45	Existing Cross Section								#REF!	#REF!	0.030	0.000016	#REF!	#REF!
W. 1. H	1,760	5	65	-6.22	-6.19	1.39	1.42	Existing Cross Section								#REF!	#REF!	0.030	0.000016	#REF!	#REF!
W. 1. B'	1,700	10	72	-3.85	-3.82	1.65	1.68	61.0	48.0	6.5	46.4	24.4	2	5.9	5.5	194.7	3.97	0.025	0.000016	0.40	78
W. 1. C1	1,000	10	72	-3.92	-3.90	1.58	1.60	61.0	48.0	6.5	46.4	24.4	2	5.9	5.5	194.7	3.97	0.025	0.000016	0.40	78
W. 1. D1	4,490	10	72	-3.99	-3.92	1.51	1.58	61.0	48.0	6.5	46.4	24.4	2	5.9	5.5	194.7	3.97	0.025	0.000016	0.40	78
W. 1. E1	2,720	10	72	-4.03	-3.99	1.47	1.51	61.0	48.0	6.5	46.4	24.4	2	5.9	5.5	194.7	3.97	0.025	0.000016	0.40	78
W. 1. F	1,180	10	72	-8.46	-6.71	1.45	1.47	Existing Cross Section								#REF!	#REF!	0.030	0.000016	#REF!	#REF!
W. 1. G	1,850	10	72	-6.19	-6.16	1.42	1.45	Existing Cross Section								#REF!	#REF!	0.030	0.000016	#REF!	#REF!
W. 1. H	1,760	10	72	-6.22	-6.19	1.39	1.42	Existing Cross Section								#REF!	#REF!	0.030	0.000016	#REF!	#REF!

TABLE 6.1 (3/4) HYDRAULIC DESIGN OF CANAL IMPROVEMENT

(Drainage Zone), Name of Canal, and Their Section	Canal Length L (m)	Design Scale/Discharge Frequency (Year)	Design Scale/Discharge Discharge Qd (m^3/s)	Bed Elevation Start (EL.m)	Bed Elevation End (EL.m)	High Water Level Start (EL.m)	High Water Level End (EL.m)	Design Cross Section Width B1 (m)	B2 (m)	B3 (m)	B4 (m)	B5 (m)	Bank Slope	Height H (m)	Height h (m)	Flow Area A (m^2)	Hydraulic Radius R (m)	Roughness Coefficient n	Canal Bed Slope i (%)	Flow Velocity V (m/s)	Discharge Capacity Qc (m3/s)
(S - Zone)																					
S. 1: R. Xom Cui - R. Ba Lao																					
S. 1. A	2,540	5	18	-2.55	-2.51	1.45	1.49	41.0	28.0	6.5	26.4	10.4	2	4.4	4.0	73.6	2.60	0.030	0.000016	0.25	18
S. 1. B1	2,510	5	23	-7.00	-4.15	1.41	1.45				Existing Cross Section					#REF!	#REF!	0.030	0.000016	#REF!	#REF!
S. 1. B2	4,000	5	17	-1.75	-3.50	1.44	1.51				Existing Cross Section					#REF!	#REF!	0.030	0.000016	#REF!	#REF!
S. 1. B3	2,060	5	17	-4.80	-1.75	1.41	1.44				Existing Cross Section					#REF!	#REF!	0.030	0.000016	#REF!	#REF!
S. 1. C	1,390	5	34	-7.30	-7.00	1.39	1.41				Existing Cross Section					#REF!	#REF!	0.030	0.000016	#REF!	#REF!
S. 2: R. Ong Lon - K. Cay Ko																					
S. 2. A1	2,020	5	12	-8.40	-6.05	1.47	1.50				Existing Cross Section					#REF!	#REF!	0.030	0.000016	#REF!	#REF!
S. 2. A2	1,900	5	12	-2.50	-1.78	1.47	1.50				Existing Cross Section					#REF!	#REF!	0.030	0.000016	#REF!	#REF!
S. 2. B	1,510	5	26	-5.90	-8.40	1.44	1.47				Existing Cross Section					#REF!	#REF!	0.030	0.000016	#REF!	#REF!
S. 2. C	3,390	5	36	-5.73	-5.90	1.39	1.44				Existing Cross Section					#REF!	#REF!	0.030	0.000016	#REF!	#REF!
S. 3: Tan - Ca Cam - Roi - Tom - Muong chuoi																					
S. 3. A	1,570	5	20	-2.95	-2.93	1.55	1.57	41.0	28.0	6.5	26.4	8.4	2	4.9	4.5	78.3	2.74	0.030	0.000016	0.26	20
S. 3. B1	2,430	5	23	-4.65	-2.95	1.51	1.55				Existing Cross Section					#REF!	#REF!	0.030	0.000016	#REF!	#REF!
S. 3. B2	3,120	5	28	-5.40	-2.55	1.51	1.56				Existing Cross Section					#REF!	#REF!	0.030	0.000016	#REF!	#REF!
S. 3. B3	3,580	5	17	-8.35	-7.95	1.51	1.57				Existing Cross Section					#REF!	#REF!	0.035	0.000016	#REF!	#REF!
S. 3. C	2,600	5	57	-9.00	-4.65	1.47	1.51				Existing Cross Section					#REF!	#REF!	0.035	0.000016	#REF!	#REF!
S. 3. D1	2,630	5	57	-12.00	-9.00	1.43	1.47				Existing Cross Section					#REF!	#REF!	0.035	0.000016	#REF!	#REF!
S. 3. D2	3,410	5	21	-7.07	-8.86	1.43	1.48				Existing Cross Section					#REF!	#REF!	0.035	0.000016	#REF!	#REF!
S. 3. E	2,410	5	64	-21.05	-12.00	1.39	1.43				Existing Cross Section					#REF!	#REF!	0.035	0.000016	#REF!	#REF!
S. 3. A	1,570	10	22	-2.95	-2.93	1.55	1.57	41.0	28.0	6.5	26.4	8.4	2	4.9	4.5	78.3	2.74	0.025	0.000016	0.31	24
S. 3. B1	2,430	10	25	-4.65	-2.95	1.51	1.55				Existing Cross Section					#REF!	#REF!	0.030	0.000016	#REF!	#REF!
S. 3. C	2,600	10	62	-9.00	-4.65	1.45	1.49				Existing Cross Section					#REF!	#REF!	0.035	0.000016	#REF!	#REF!
S. 3. D1	2,630	10	62	-12.00	-9.00	1.42	1.46				Existing Cross Section					#REF!	#REF!	0.035	0.000016	#REF!	#REF!
S. 3. E	2,410	10	69	-21.05	-12.00	1.39	1.43				Existing Cross Section					#REF!	#REF!	0.035	0.000016	#REF!	#REF!
S. 4: R. Cau Kinh																					
S. 4. A	1,920	5	19	-3.10	-1.65	1.39	1.49				Existing Cross Section					#REF!	#REF!	0.030	0.000050	#REF!	#REF!
S. 5: R. AP3Phu My																					
S. 5. A	1,860	5	18	-4.30	-1.25	1.39	1.48				Existing Cross Section					#REF!	#REF!	0.030	0.000050	#REF!	#REF!
(NE - Zone)																					
NE. 1: R. Ong Dua																					
NE. 1. A	1,500	5	18	-2.18	-2.15	1.32	1.35	41.0	28.0	6.5	26.4	12.4	2	3.9	3.5	67.9	2.42	0.030	0.000020	0.27	18
NE. 2: R. Go Dua																					
NE. 2. A	2,570	5	30	-3.14	-3.08	1.36	1.42	45.0	32.0	6.5	30.4	12.4	2	4.9	4.5	96.3	2.96	0.030	0.000020	0.31	30
NE. 2. B	2,200	5	36	-3.18	-3.14	1.32	1.36	49.1	36.1	6.5	34.5	16.5	2	4.9	4.5	114.8	3.33	0.030	0.000020	0.32	37
NE. 3: R. Thu Duc																					
NE. 3. A	2,140	5	23	-2.68	-2.63	1.32	1.37	41.0	28.0	6.5	26.4	10.4	2	4.4	4.0	73.6	2.60	0.030	0.000025	0.32	23
NE. 4: R. Truong Tho																					
NE. 4. A	2,170	5	14	-2.7	-2.63	1.32	1.37	35.0	22.0	6.5	20.4	4.4	2	4.4	4.0	49.6	2.23	0.030	0.000025	0.28	14
NE. 5: R. Nhum - K. Cau - R. Go Gong																					
NE. 5. A1	3,350	5	83	0.65	9.03	3.65	12.03	29.0	19.0	5.0	17.4	5.4	2	3.4	3.0	34.2	1.82	0.030	0.002500	2.48	85
NE. 5. A2	2,340	5	47	0.65	7.34	3.65	10.34	24.5	14.5	5.0	12.9	0.9	2	3.4	3.0	20.7	1.45	0.030	0.002857	2.28	47
NE. 5. B	1,700	5	133	-2.35	-0.35	1.65	3.65	35.5	25.5	5.0	23.9	7.9	2	4.4	4.0	63.6	2.47	0.030	0.001176	2.09	133
NE. 5. C	2,830	5	133	-4.42	-4.35	1.58	1.65	75.0	62.0	6.5	60.4	36.4	2	6.4	6.0	290.4	4.59	0.030	0.000025	0.46	134
NE. 5. D1	4,440	5	133	-4.53	-4.42	1.47	1.58	75.0	62.0	6.5	60.4	36.4	2	6.4	6.0	290.4	4.59	0.030	0.000025	0.46	134

TABLE 6.1 (4/4) HYDRAULIC DESIGN OF CANAL IMPROVEMENT

(Drainage Zone), Name of Canal, and Their Section	Canal Length L (m)	Design Scale/Discharge Frequency (Year)	Design Scale/Discharge Discharge Qd (m^3/s)	Bed Elevation Start (EL.m)	Bed Elevation End (EL.m)	High Water Level Start (EL.m)	High Water Level End (EL.m)	Design Cross Section Width B1 (m)	B2 (m)	B3 (m)	B4 (m)	B5 (m)	Bank Slope	Height H (m)	Height h (m)	Flow Area A (m^2)	Hydraulic Radius R (m)	Roughness Coefficient n	Canal Bed Slope i (%)	Flow Velocity V (m/s)	Discharge Capacity Qc (m^3/s)
NE. 5. A1	3,350	10	93	0.65	9.03	3.65	12.03	29.0	19.0	5.0	17.4	5.4	2	3.4	3.0	34.2	1.82	0.025	0.002500	2.98	102
NE. 5. A2	2,340	10	53	0.65	7.34	3.65	10.34	24.5	14.5	5.0	12.9	0.9	2	3.4	3.0	20.7	1.45	0.025	0.002857	2.73	57
NE. 5. B	1,700	10	149	-2.35	-0.35	1.65	3.65	35.5	25.5	5.0	23.9	7.9	2	4.4	4.0	63.6	2.47	0.025	0.001176	2.51	159
NE. 5. C	2,830	10	149	-4.42	-4.35	1.58	1.65	75.0	62.0	6.5	60.4	36.4	2	6.4	6.0	290.4	4.59	0.025	0.000025	0.55	161
NE. 5. D1	4,440	10	149	-4.53	-4.42	1.47	1.58	75.0	62.0	6.5	60.4	36.4	2	6.4	6.0	290.4	4.59	0.025	0.000025	0.55	161
(SE - Zone)																					
SE. 1: R. Binh Khanh																					
SE. 1. A	2,320	5	12	-3.96	-2.45	1.47	1.53	Existing Cross Section								#REF!	#REF!	0.030	0.000025	#REF!	#REF!
SE. 2: R. Ca Tre Nho																					
SE. 2. A	2,080	5	22	-4.20	-1.10	1.47	1.52	Existing Cross Section								#REF!	#REF!	0.030	0.000025	#REF!	#REF!
SE. 3: R. Da Do																					
SE. 3. A	2,500	5	12	-2.70	-2.34	1.47	1.53	Existing Cross Section								#REF!	#REF!	0.030	0.000025	#REF!	#REF!
SE. 4: R. Giong Ong To																					
SE. 4. A	3,410	5	18	-2.13	-1.36	1.52	1.61	Existing Cross Section								#REF!	#REF!	0.030	0.000025	#REF!	#REF!
SE. 4. B	2,050	5	19	-3.93	-2.13	1.47	1.52	Existing Cross Section								#REF!	#REF!	0.030	0.000025	#REF!	#REF!
SE. 5: R. Muong																					
SE. 5. A	1,110	5	23	-2.03	-2.00	1.47	1.50	40.0	30.0	5	28.4	14.4	2	3.9	3.5	74.9	2.49	0.030	0.000025	0.31	23
SE. 6: R. Ky Ha																					
SE. 6. A	4,390	5	24	-2.23	-2.12	1.47	1.58	40.0	30.0	5	28.4	13.6	2	4.1	3.7	77.7	2.58	0.030	0.000025	0.31	24
SE. 7: R. Kinh Ong Hong - R. Chuiec																					
SE. 7. A	2,500	5	38	-2.97	-2.92	1.53	1.58	51.0	38.0	6.5	36.4	18.4	2	4.9	4.5	123.3	3.20	0.030	0.000020	0.32	40
SE. 7. B	3,200	5	38	-5.66	-3.12	1.47	1.53	Existing Cross Section								360.0	4.00	0.030	0.000020	0.38	135
SE. 8: R. Ong Cay - R. Ba Cua - R. Ong Kuou																					
SE. 8. A	1,950	5	12	-2.00	-1.61	1.55	1.59	Existing Cross Section								#REF!	#REF!	0.030	0.000020	#REF!	#REF!
SE. 8. B	4,120	5	27	-1.03	-2	1.47	1.55	Existing Cross Section								#REF!	#REF!	0.030	0.000020	#REF!	#REF!
SE. 9: R. Tan - R. Ong Nhieu																					
SE. 9. A	2,470	5	51	-2.93	-2.89	1.57	1.61	58.0	45.0	6.5	43.4	40.0	2	4.9	4.5	187.7	3.12	0.030	0.000014	0.27	51
SE. 9. B	4,240	5	51	-5.25	-2.94	1.51	1.57	Existing Cross Section								#REF!	#REF!	0.030	0.000014	#REF!	#REF!
SE. 9. C	2,830	5	51	-6.69	-5.25	1.47	1.51	Existing Cross Section								#REF!	#REF!	0.030	0.000014	#REF!	#REF!
SE. 10: Tac River																					
SE. 10. A	3,620	5	19	-6.56	-5.49	1.56	1.61	Existing Cross Section								#REF!	#REF!	0.035	0.000014	#REF!	#REF!
SE. 10. B	4,080	5	35	-6.83	-6.56	1.50	1.56	Existing Cross Section								#REF!	#REF!	0.035	0.000014	#REF!	#REF!
SE. 10. C	2,410	5	216	-8.95	-6.83	1.47	1.50	Existing Cross Section								#REF!	#REF!	0.035	0.000014	#REF!	#REF!
SE. 10. A	3,620	10	21	-6.56	-5.49	1.56	1.61	Existing Cross Section								#REF!	#REF!	0.030	0.000014	#REF!	#REF!
SE. 10. B	4,080	10	38	-6.83	-6.56	1.50	1.56	Existing Cross Section								#REF!	#REF!	0.030	0.000014	#REF!	#REF!
SE. 10. C	2,410	10	243	-8.95	-6.83	1.47	1.50	Existing Cross Section								#REF!	#REF!	0.030	0.000014	#REF!	#REF!

TABLE 6.2 SUMMARY OF BILL OF QUANTITES ON CANAL IMPROVEMENT

Item (Drainage Zone) Name of Canal Canal Section	Canal Length L (m)	Excavation/ Dredging (E/D) (m3)	Bank Protection					O/M Road		Road and Railway Crossing		Land Acquisition (LA) (m2)
			Type (T)	Existing Bank Reformation (BR) (m2)	Grass (Sod) (GS) (m2)	Stone Masonry (SM) (m2)	Concrete Wall (CW) (m2)	Filling (F) (m3)	Pavement (P) (m2)	Box Culvert (BC) Number (place)	Bridge (BR) Number (Bridge Area) (Place) (m2)	
(C - Zone)												
C. 1: Nhieu Loc - Thi Nghe	8,930	708,663	C	-	-	187,983	-	54,795	71,440	-	-	157,365
C. 2: Cau Son - Tau Vat Tat	3,500	13,055	C	-	-	50,116	-	34,691	28,000	-	-	49,310
C. 3: Tan Hoa - Lo Gom	8,570	674,003	C,D	-	-	68,022	39,091	16,355	68,560	-	(2) (862)	176,373
C. 4: Tau Hu - Ben Nghe, Doi - Te	34,330	819,154	A,B,C	128,030	188,918	413,038	-	191,309	274,640	-	-	308,151
(1) R. Ba Tang	3,330	39,014	A,B	14,000	34,818	-	-	37,059	26,640	-	-	60,151
(2) R. Ba Lon	5,740	3,545	A,B	22,260	62,330	-	-	52,772	45,920	-	-	45,920
(3) Tau Hu - Ben Nghe	12,150	776,595	C	-	-	413,038	-	58,444	97,200	-	(2) (527)	97,200
(4) Doi - Te	13,110	-	A	91,770	91,770	-	-	43,034	104,880	-	-	104,880
Sub-total	55,330	2,214,875		128,030	188,918	719,159	39,091	297,150	442,640	-	(4) (1,389)	691,199
(N - Zone)												
N. 1: Ben Da - Ba Hong	9,500	101,731	B	56,505	148,698	-	-	63,127	76,000	2	-	127,701
N. 2: Tham Luong - Ben Cat	47,880	2,516,654	B,C	128,351	516,845	323,224	-	327,555	264,160	2	(7) (2,483)	924,491
(1) 5- year	33,020	2,516,654	B	128,351	516,845	-	-	327,555	264,160	2	(7) (2,483)	924,491
(2) 10-year	14,860	-	C	-	-	323,224	-	-	-	-	-	-
Sub-total	57,380	2,618,385		184,856	665,543	323,224	-	390,682	340,160	4	(7) (2,483)	1,052,192
(W - Zone)												
W. 1: R. Cua - R. Nuoc Len	46,170	1,638,837	A,B,C	77,350	394,155	261,482	-	404,299	251,040	-	(3) (1,181)	808,067
(1) 5-year	31,380	1,638,837	A,B	77,350	394,155	-	-	404,299	251,040	-	(3) (1,181)	808,067
(2) 10-year	14,790	-	A,C	-	-	261,482	-	-	-	-	-	-
Total	46,170	1,638,837		77,350	394,155	261,482	-	404,299	251,040	-	(3) (1,181)	808,067
(S - Zone)												
S. 1: R. Xom Cui - R. Ba Lao	12,500	2,212	A,B	69,720	109,477	-	-	138,128	100,000	-	-	163,764
S. 2: R. Ong Lon - K. Cay Ko	8,820	-	A	61,740	61,740	-	-	92,855	70,560	-	-	104,617
S. 3: Tan - Ca Cam - Roi - Tom - Muong chuoi	33,390	-	A,B,C	63,424	63,424	34,404	-	286,445	174,000	-	-	275,809
(1) 5-year	21,750	-	A,B	63,424	63,424	-	-	286,445	174,000	-	-	275,809
(2) 10-year	11,640	-	A,C	-	-	34,404	-	-	-	-	-	-
S. 4: R. Cau Kinh	1,920	-	A	13,440	13,440	-	-	29,127	15,360	-	-	24,338
S. 5: R. AP3Phu My	1,860	-	A	13,020	13,020	-	-	28,687	14,880	-	-	23,651
Sub-total	58,490	2,212		221,344	261,101	34404	-	575,242	374,800	-	-	592,179
(NE - Zone)												
NE. 1 R. Ong Dua	2,250	66,877	B	-	35,218	-	-	14,943	18,000	-	-	35,944
NE. 2: R. Go Dua	4,770	38,573	B	34,435	74,662	-	-	47,507	38,160	-	-	70,636
NE. 3: R. Thu Duc	2,140	76,988	B	-	33,496	-	-	5,918	17,120	-	(1) (228)	35,660
NE. 4: R. Truong Tho	2,170	55,873	B	-	33,966	-	-	57,784	17,360	-	(1) (211)	77,023
NE. 5: R. Nhum - R. Cau - R. Go Gong	29,320	2,612,667	B,C	-	229,466	328,049	-	38,965	117,280	-	-	540,851
(1) 5- year	14,660	2,612,667	B	-	229,466	-	-	38,965	117,280	-	(3) (1,017)	540,851
(2) 10-year	14,660	-	C	-	-	328,049	-	-	-	-	-	-
Sub-total	40,650	2,850,978		34,435	406,808	328,049	-	165,117	207,920	-	(5) (1,456)	760,114
(SE - Zone)												
SE. 1: R. Binh Khanh	2,320	-	A	16,240	16,240	-	-	1,651	18,560	-	-	23,528
SE. 2: R. Ca Tre Nho	2,080	-	A	14,560	14,560	-	-	5,079	16,640	-	-	21,792
SE. 3: R. Da Do	2,500	-	A	17,500	17,500	-	-	11,110	20,000	-	-	27,131
SE. 4: R. Giong Ong To	5,460	-	A	38,220	38,220	-	-	13,917	43,680	-	-	57,310
SE. 5: R. Muong	1,110	37,017	B	-	17,374	-	-	-	8,880	-	-	11,100
SE. 6: R. Ky Ha	4,390	90,090	B	-	68,714	-	-	-	35,120	-	-	43,900
SE. 7: R. Kinh Ong Hong - R. Chuiee	5,700	-	A,B	61,531	61,531	-	-	38,877	45,600	-	-	72,645
SE. 8: R. Ong Cay - R. Ba Cua - R. Ong Kieu	6,070	-	A	42,490	42,490	-	-	5,265	48,560	-	-	61,740
SE. 9: R. Tan - R. Ong Nhieu	9,540	-	A	49,490	88,152	-	-	80,724	76,320	-	-	157,149
SE. 10: Tac River	10,110	-	A	-	-	-	-	46,161	80,880	-	-	109,941
Sub-total	49,280	127,107		240,031	364,781	0	0	202,784	394,240	-	-	586,236
Total	307,300	9,452,394		886,046	2,281,306	1,666,318	39,091	2,035,274	2,010,800	4	(19)(6,509)	4,469,987

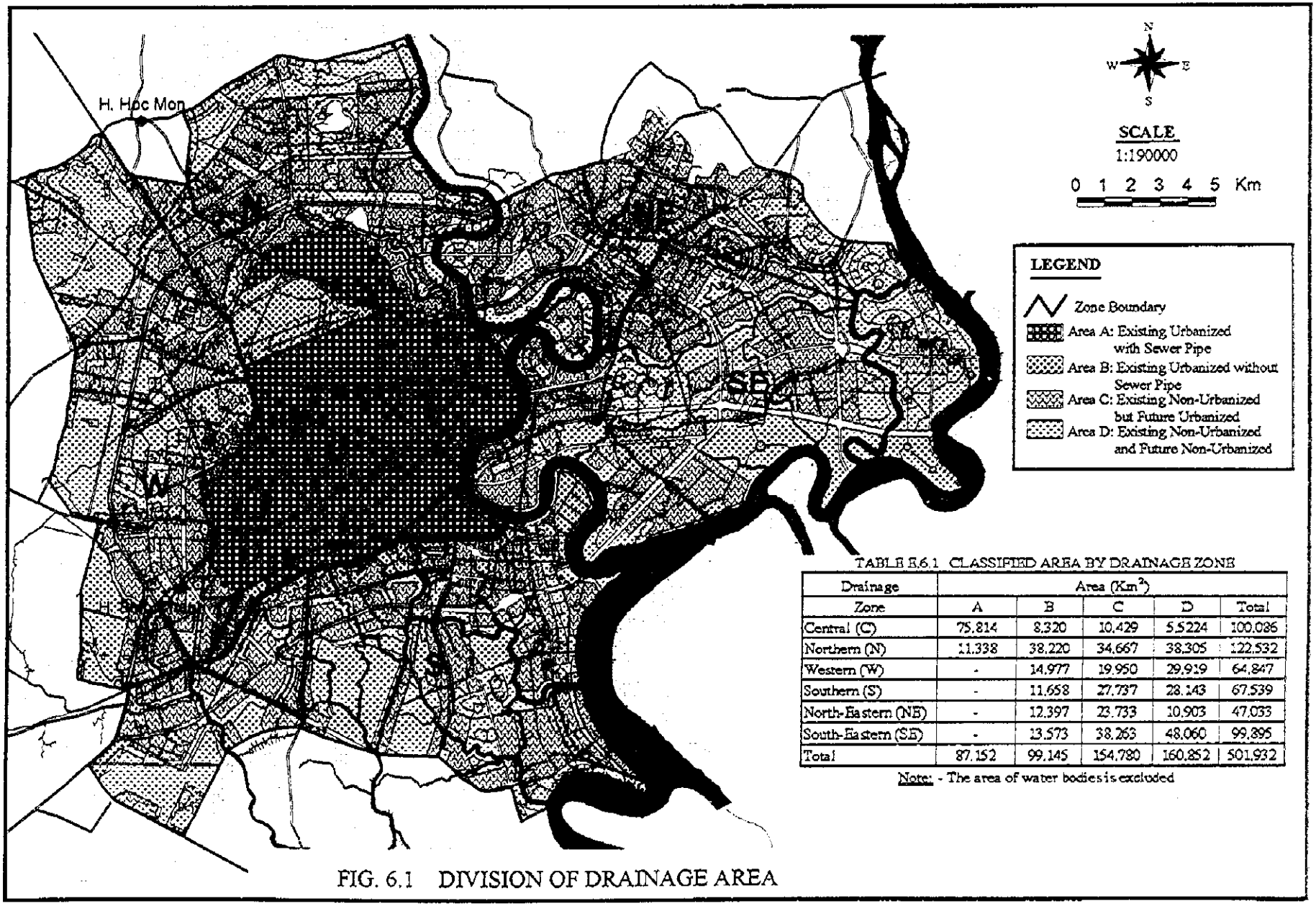


TABLE 5.6.1 CLASSIFIED AREA BY DRAINAGE ZONE

Drainage	Area (Km^2)				
Zone	A	B	C	D	Total
Central (C)	75.814	8.320	10.429	5.5224	100.086
Northern (N)	11.338	38.220	34.667	38.305	122.532
Western (W)	-	14.977	19.950	29.919	64.847
Southern (S)	-	11.658	27.737	28.143	67.539
North-Eastern (NE)	-	12.397	23.733	10.903	47.033
South-Eastern (SE)	-	13.573	38.263	48.060	99.895
Total	87.152	99.145	154.780	160.852	501.932

Note: - The area of water bodies is excluded

FIG. 6.1 DIVISION OF DRAINAGE AREA

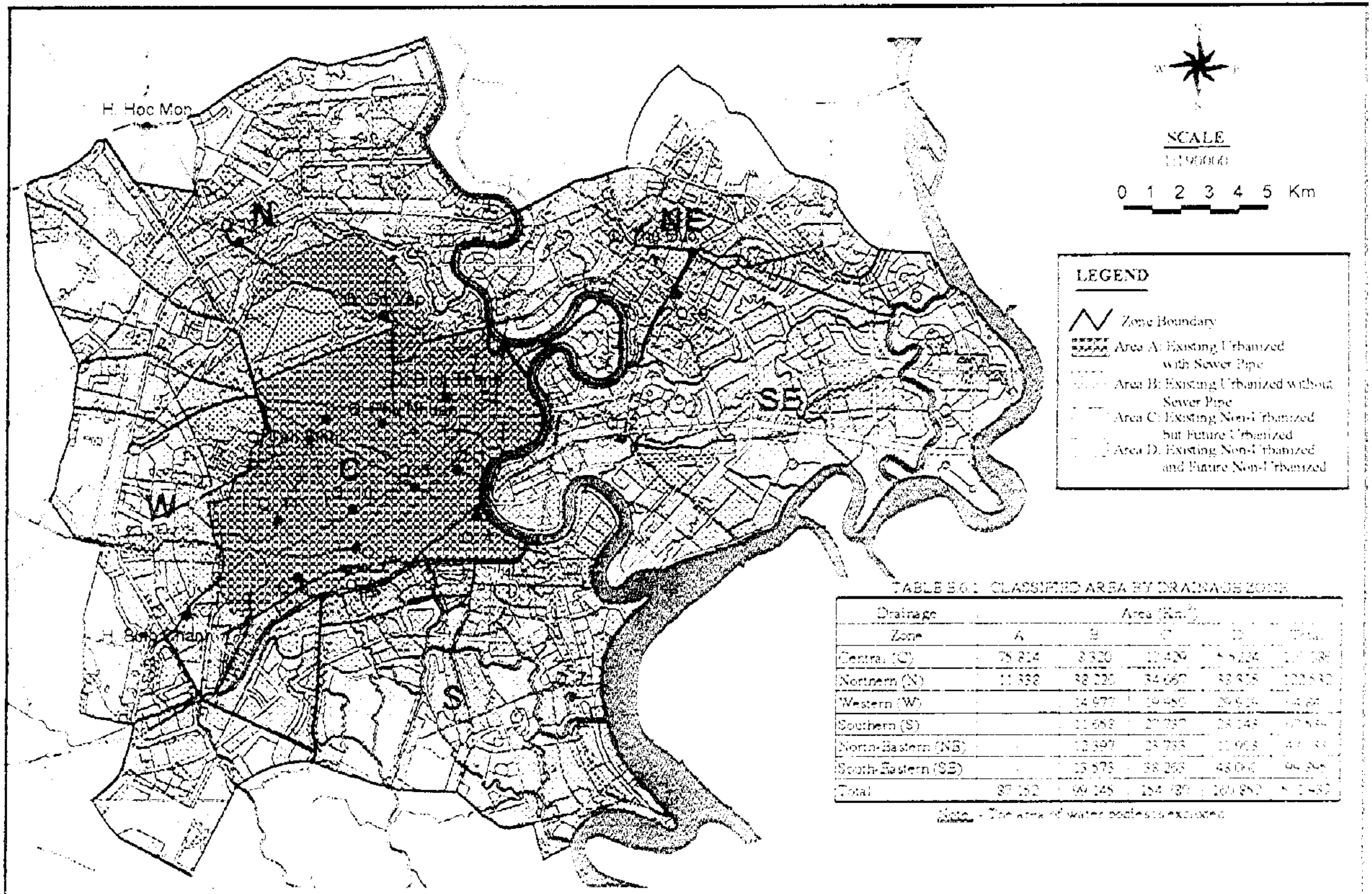
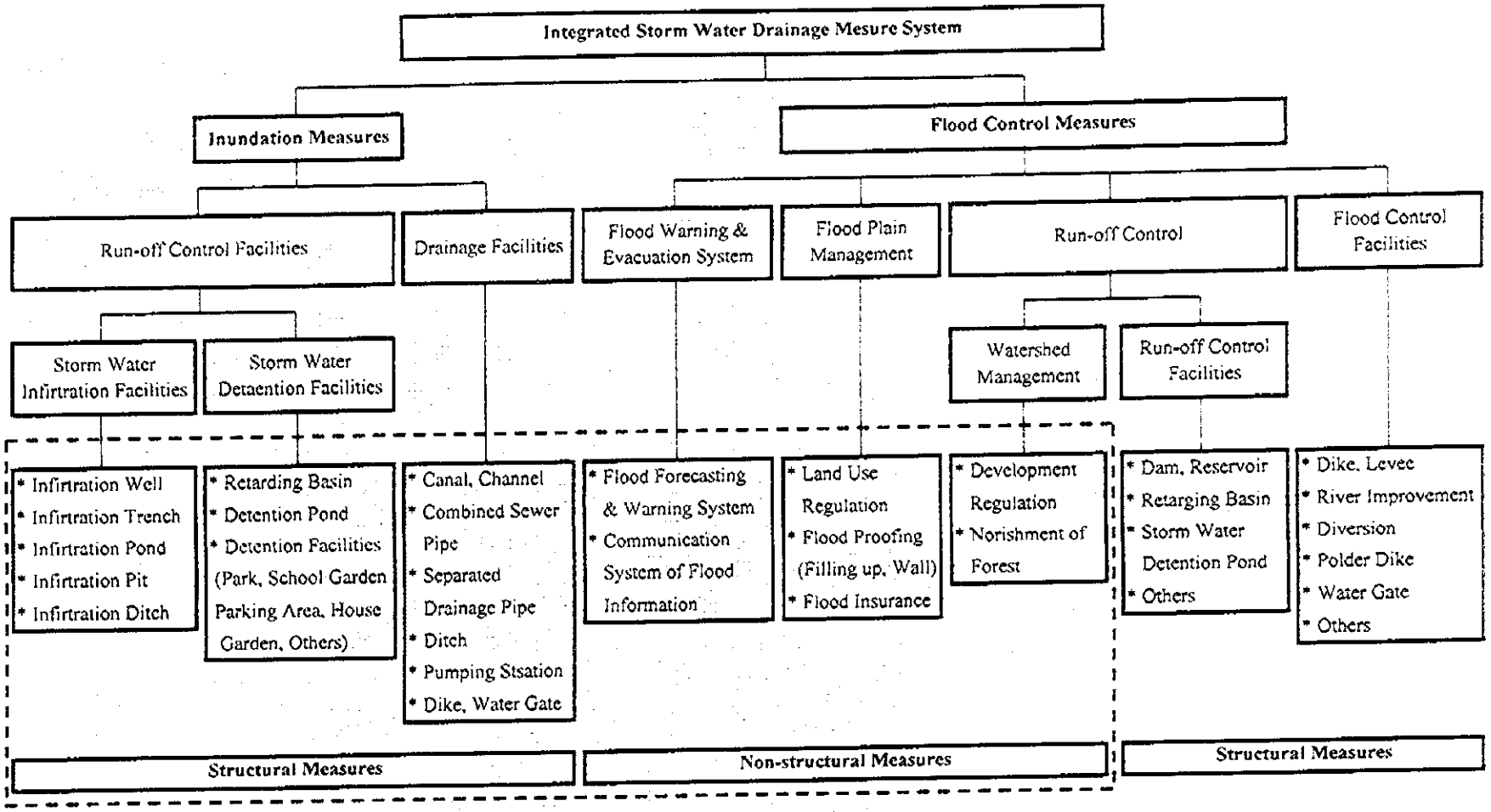


TABLE B.6.1 CLASSIFIED AREA BY DRAINAGE ZONE

Drainage	Area (Km²)				
Zone	A	B	C	D	Total
Central (C)	75.814	8.320	11.429	[illegible]	[illegible]
Northern (N)	11.338	38.220	34.667	[illegible]	[illegible]
Western (W)		14.977	[illegible]	[illegible]	[illegible]
Southern (S)		11.658	[illegible]	[illegible]	[illegible]
North-Eastern (NE)		12.397	[illegible]	[illegible]	[illegible]
South-Eastern (SE)		13.573	38.265	[illegible]	[illegible]
Total	87.152	99.145	[illegible]	[illegible]	[illegible]

Note : The area of water bodies is excluded.

FIG. 6.1 DIVISION OF DRAINAGE AREA



Note: 1. Measures enclosed in a broken line are proposed in this Master Plan.

2. Retaining wall, dike and levee for flood protection of low land areas are to be included in this Master Plan.

FIG. 6.2 PROPOSED INTEGRATED STORMWATER DRAINAGE MEASURE SYSTEM

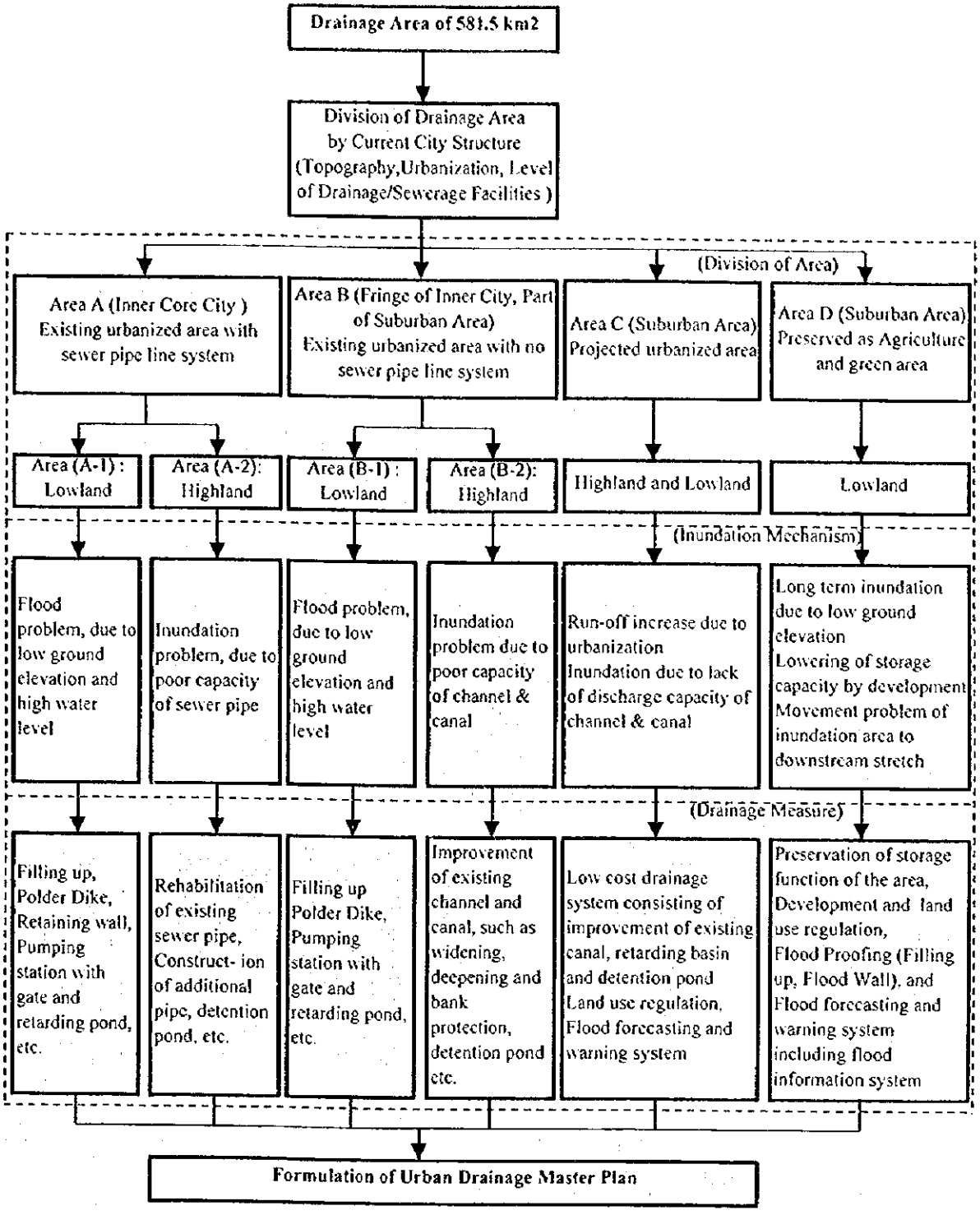


FIG. 6.3 PROCEDURE FOR SELECTION OF INTEGRATED URBAN DRAINAGE MEASURES

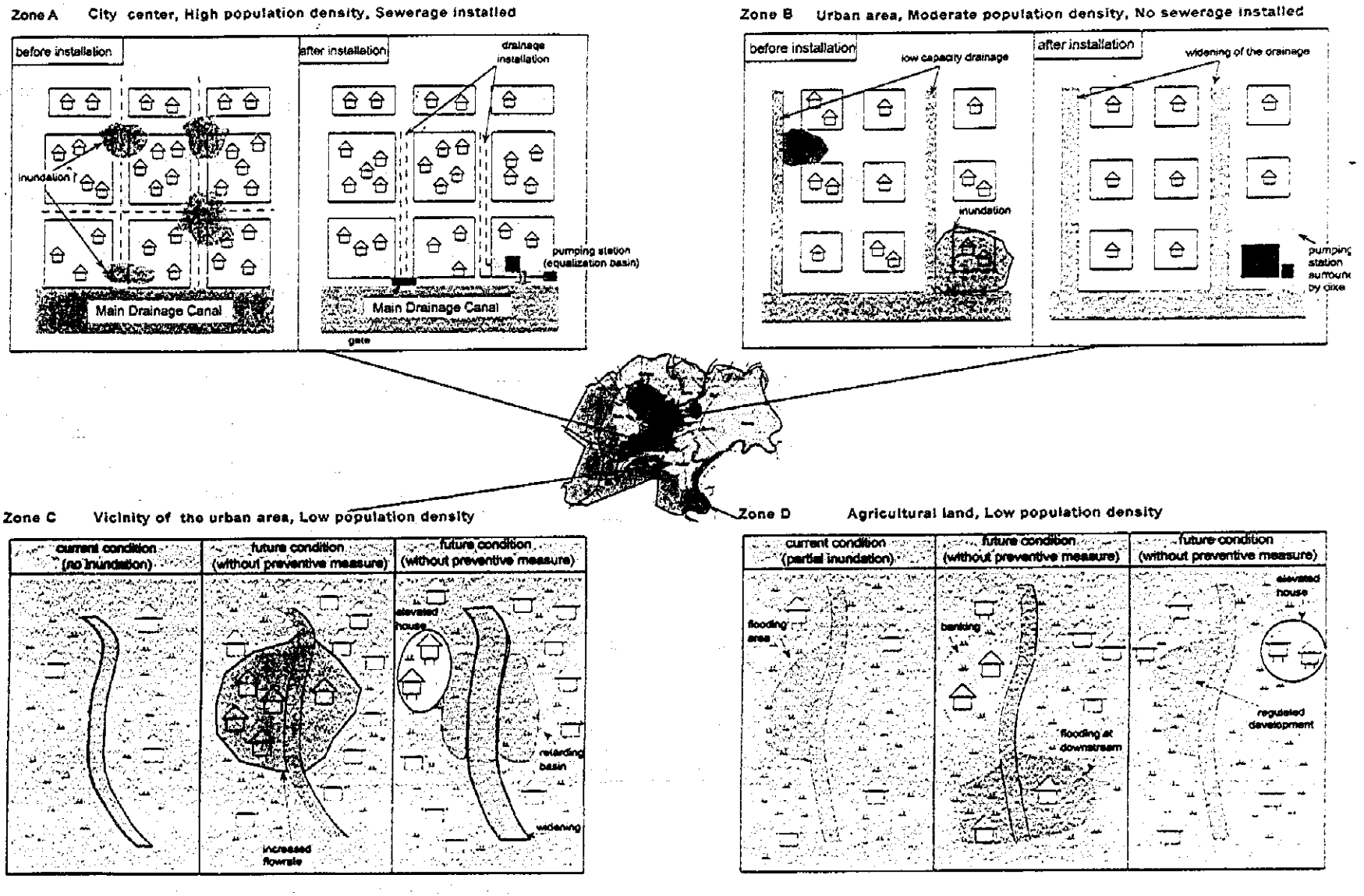
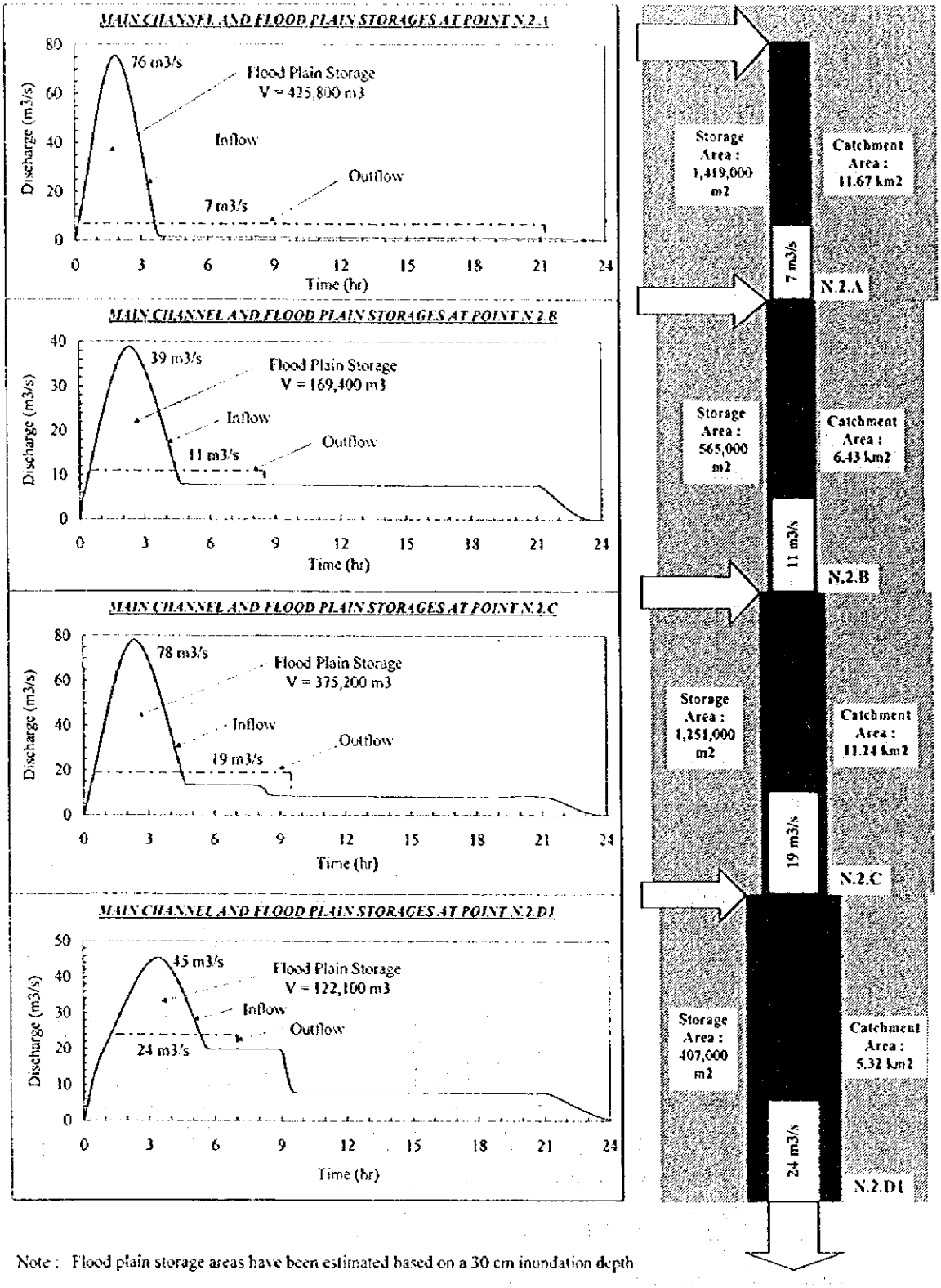


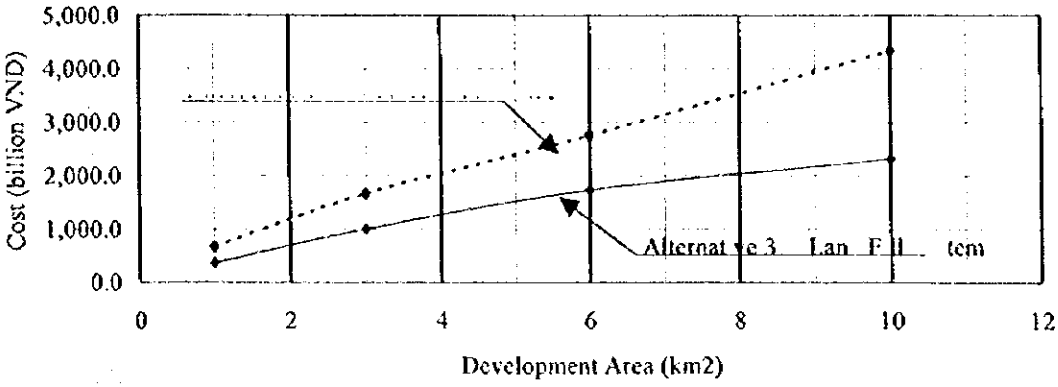
Fig. 6.4 Concept of Installation of Drainage Facilities



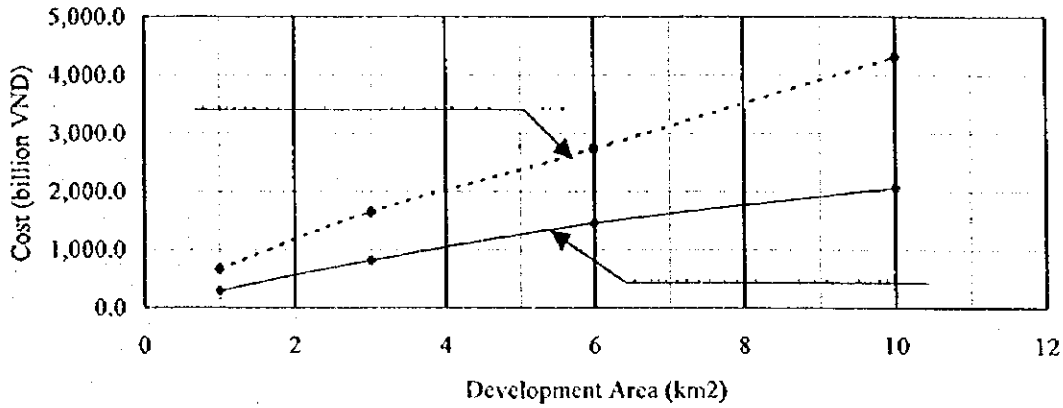
Note : Flood plain storage areas have been estimated based on a 30 cm inundation depth

FIG. 6.5 FLOOD PLAIN STORAGES ALONG RACH DAIHAN (5-Year R.P.)

(EXISTING GROUND ELEVATION: GL.0.6 m above MSL)



(EXISTING GROUND ELEVATION: GL.0.9 m above MSL)



(EXISTING GROUND ELEVATION: GL.1.2 m above MSL)

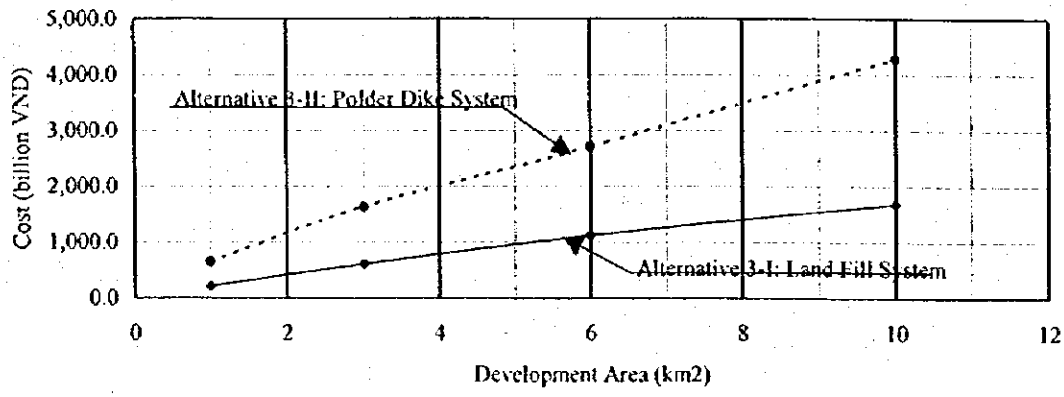
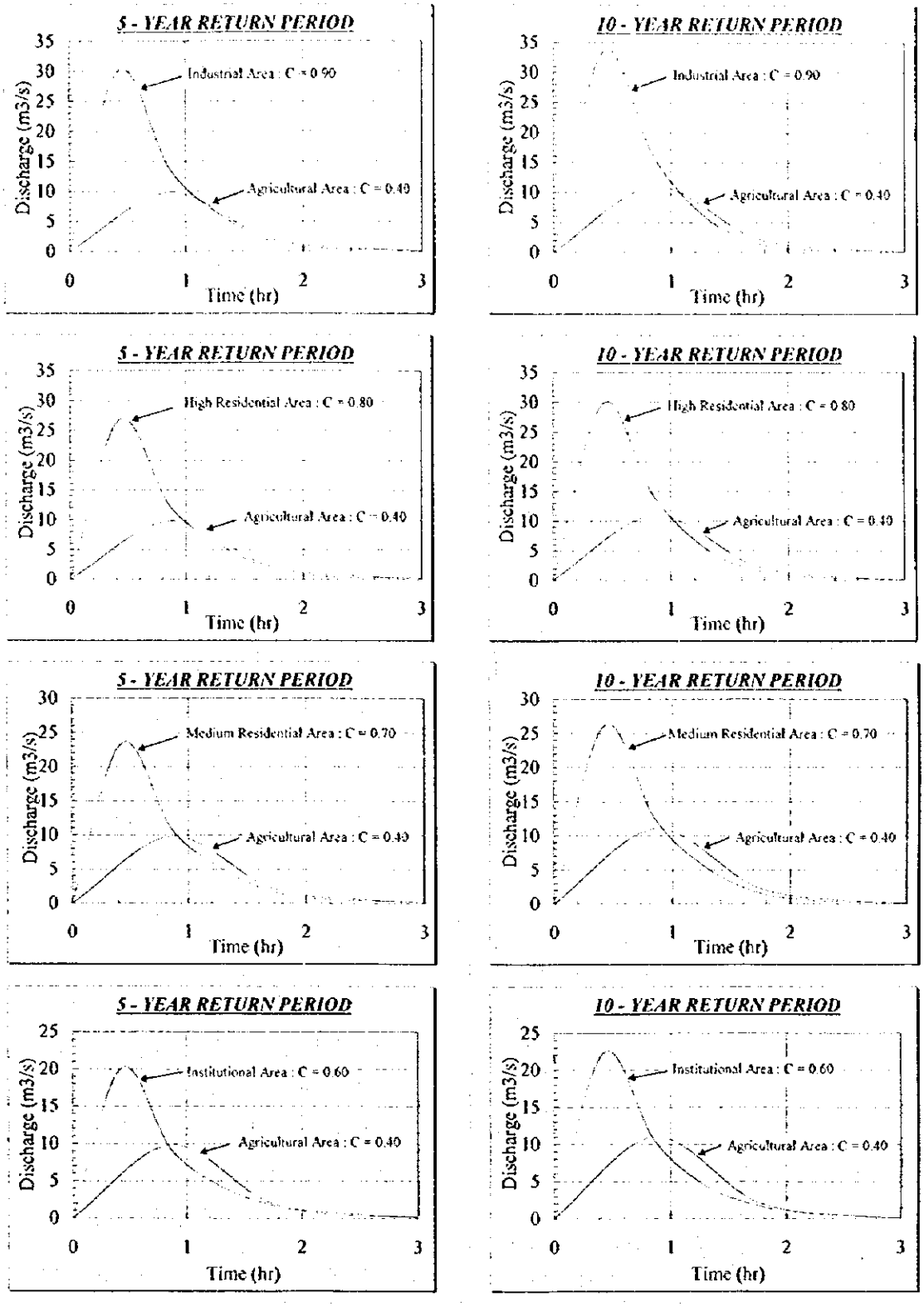


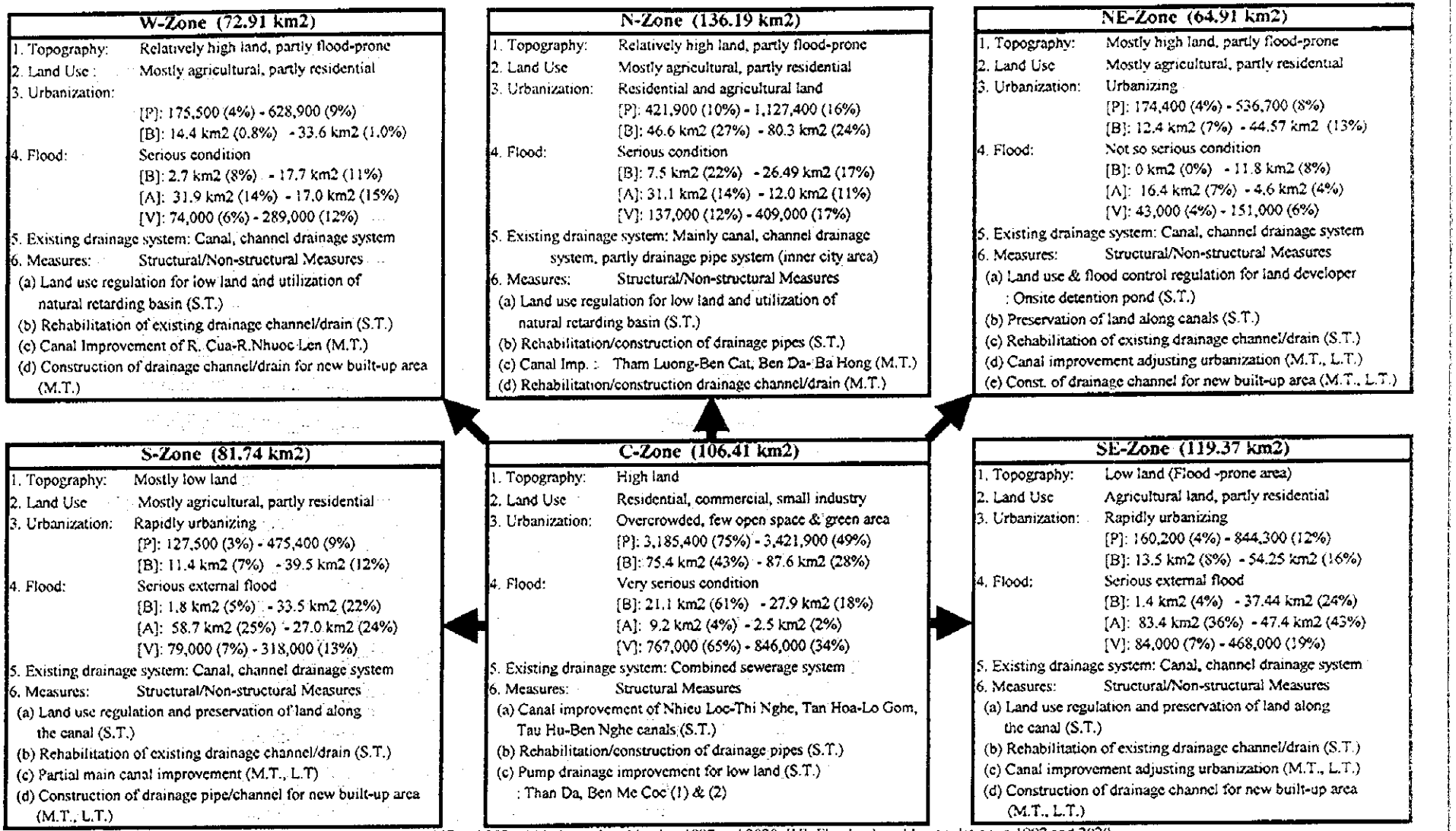
FIG. 6.6 COST COMPARISON OF ALTERNATIVES 3-I AND 3-II



For non-urbanized area (C = 0.40) : Time of concentration = 10 + 1.25 * 1000/(0.5*60) = 51.67 minutes.
For urbanized area (C = 0.60, 0.70, 0.80, 0.90) : Time of concentration = 5 + 1.25 * 1000/(1.0*60) = 25.83 minutes.

Required specific storage volume (m3/km2) due to urbanization

FIG. 6.7 EFFECT OF URBANIZATION ON RUNOFF HYDROGRAPHS (A = 1.0 km2)



Legend: [P]: Population in 1997 and 2020, [B]: Built-up area in 1997 and 2020, [A]: Agricultural land in 1997 and 2020, [V]: Flood vulnerable population in 1997 and 2020
(S.T.): Short Term, (M.T.): Mid. Term, (L.T.): Long Term

FIG. 6.8 OUTLINE OF PROPOSED URBAN DRAINAGE IMPROVEMENT PLAN BY ZONE

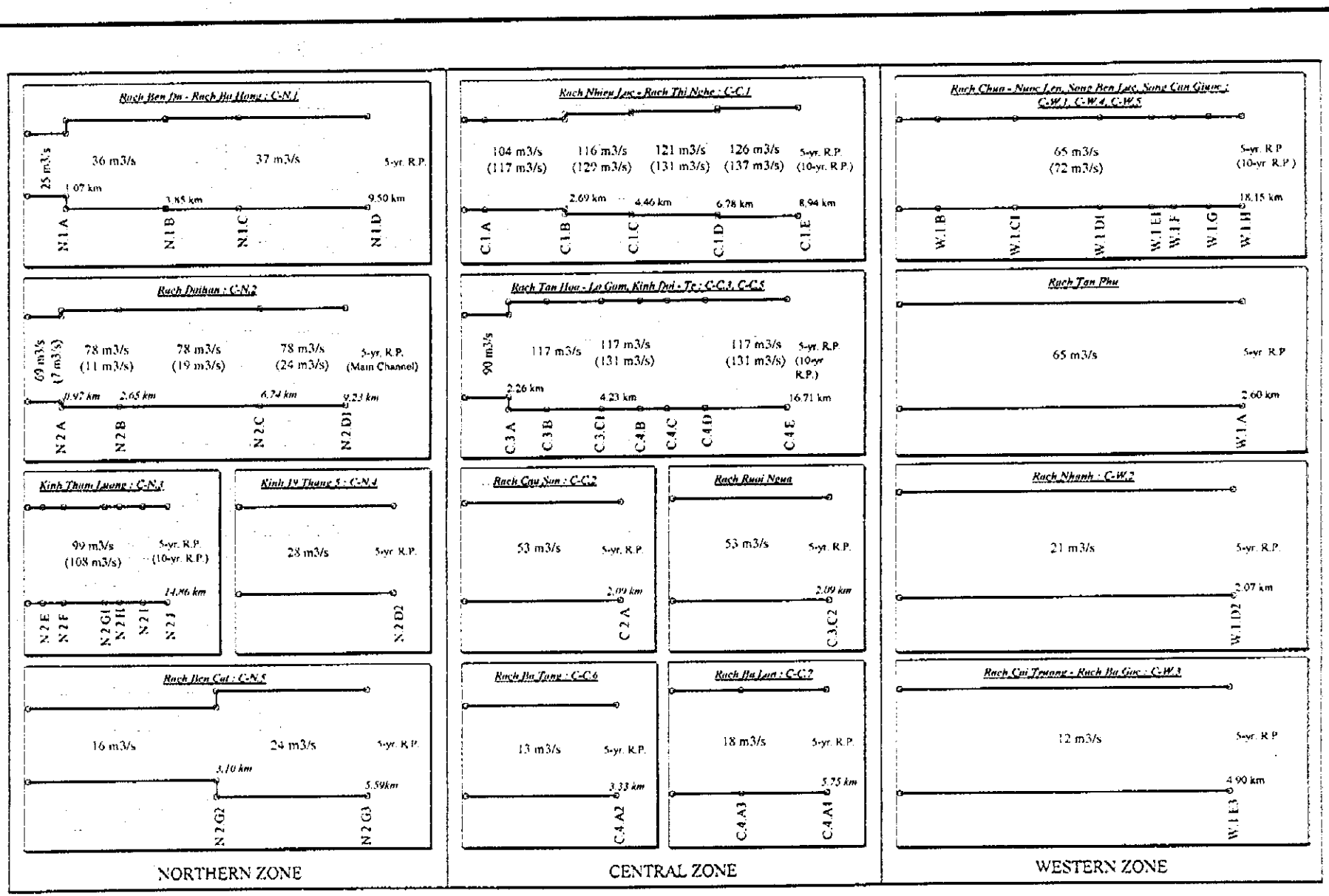


FIG. 6.9 (1/3) DESIGN DISCHARGE DISTRIBUTIONS OF THE CANALS

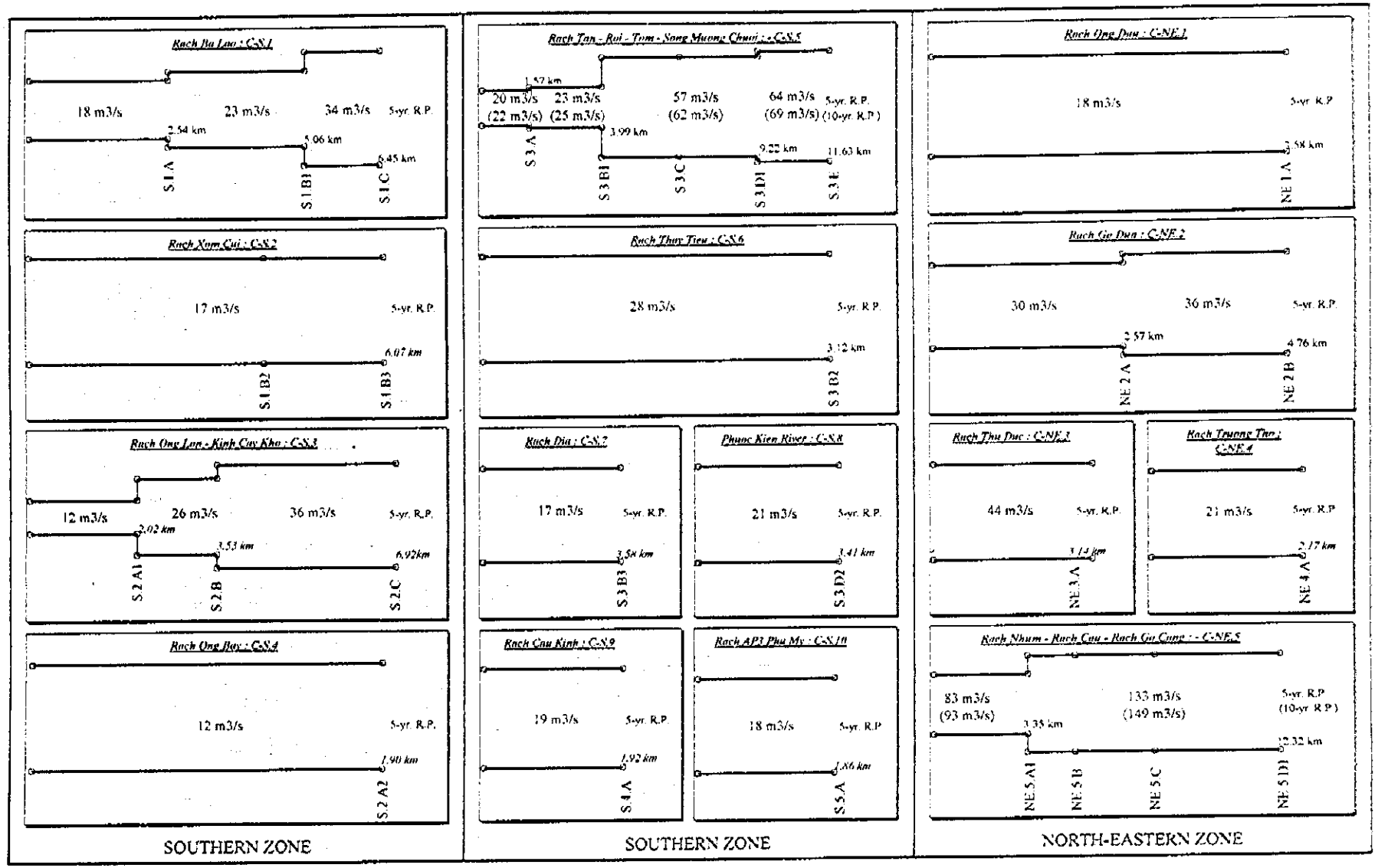


FIG. 6.9 (2/3) DESIGN DISCHARGE DISTRIBUTIONS OF THE CANALS

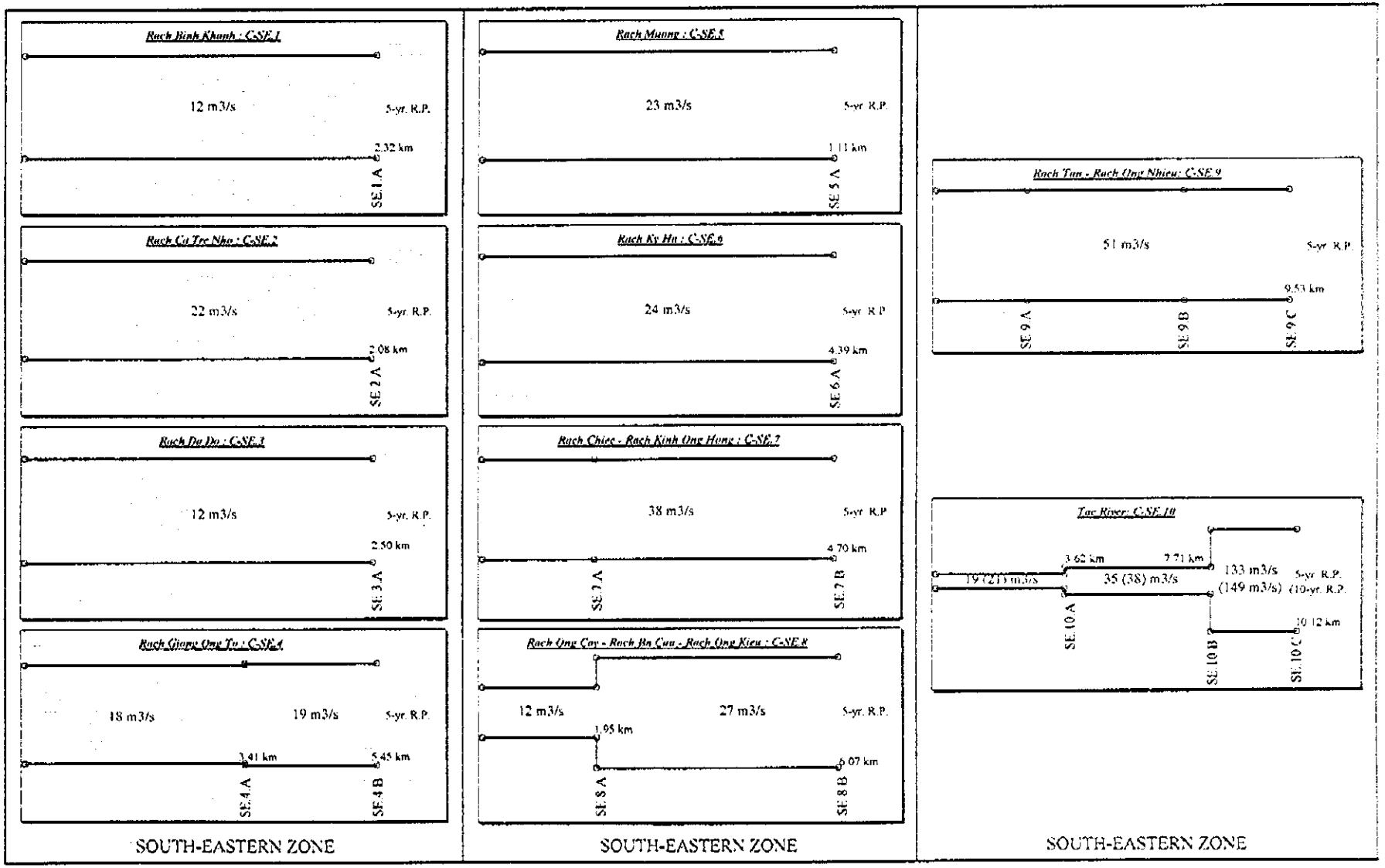


FIG. 6.9 (3/3) DESIGN DISCHARGE DISTRIBUTIONS OF THE CANALS

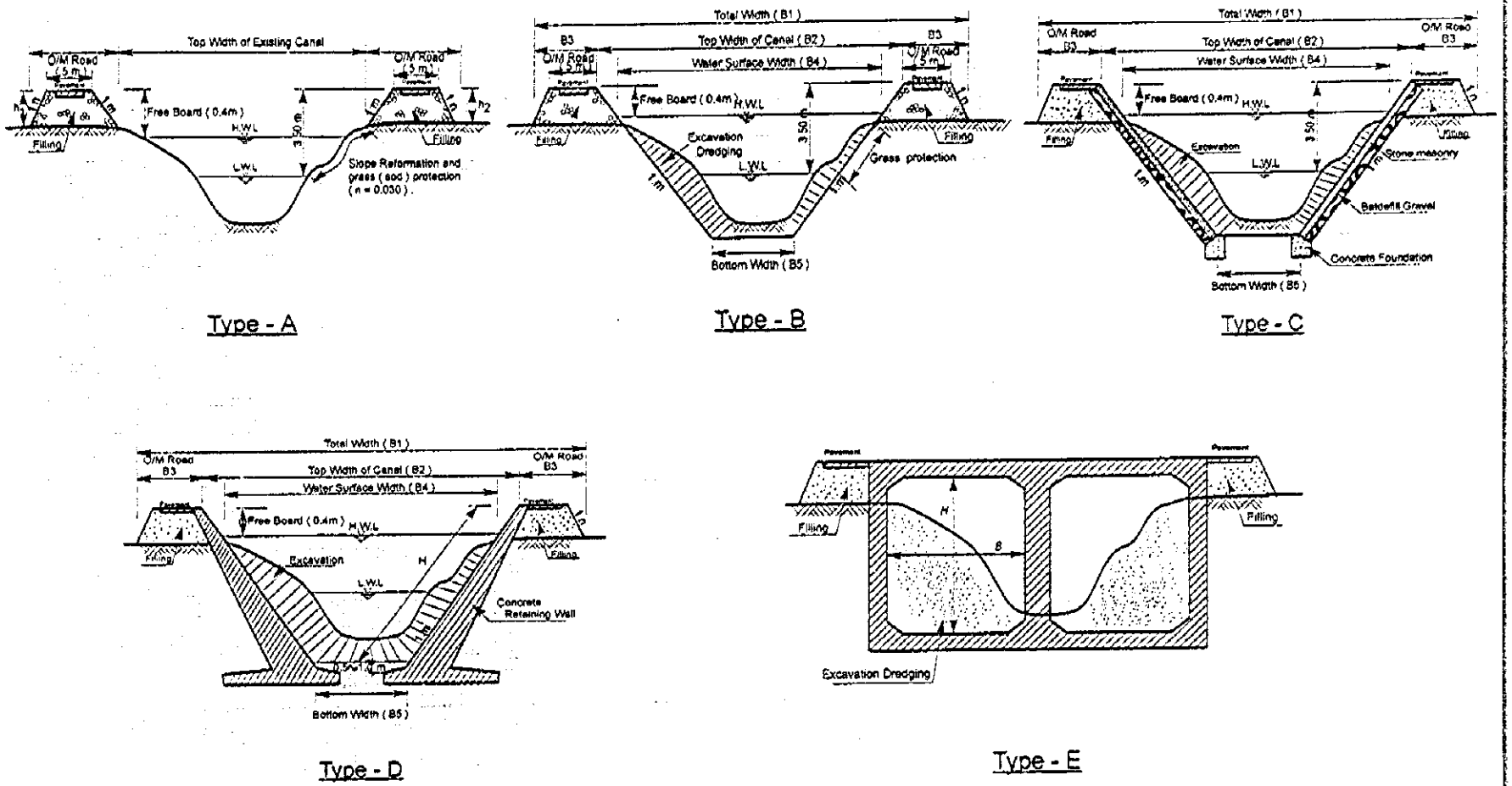
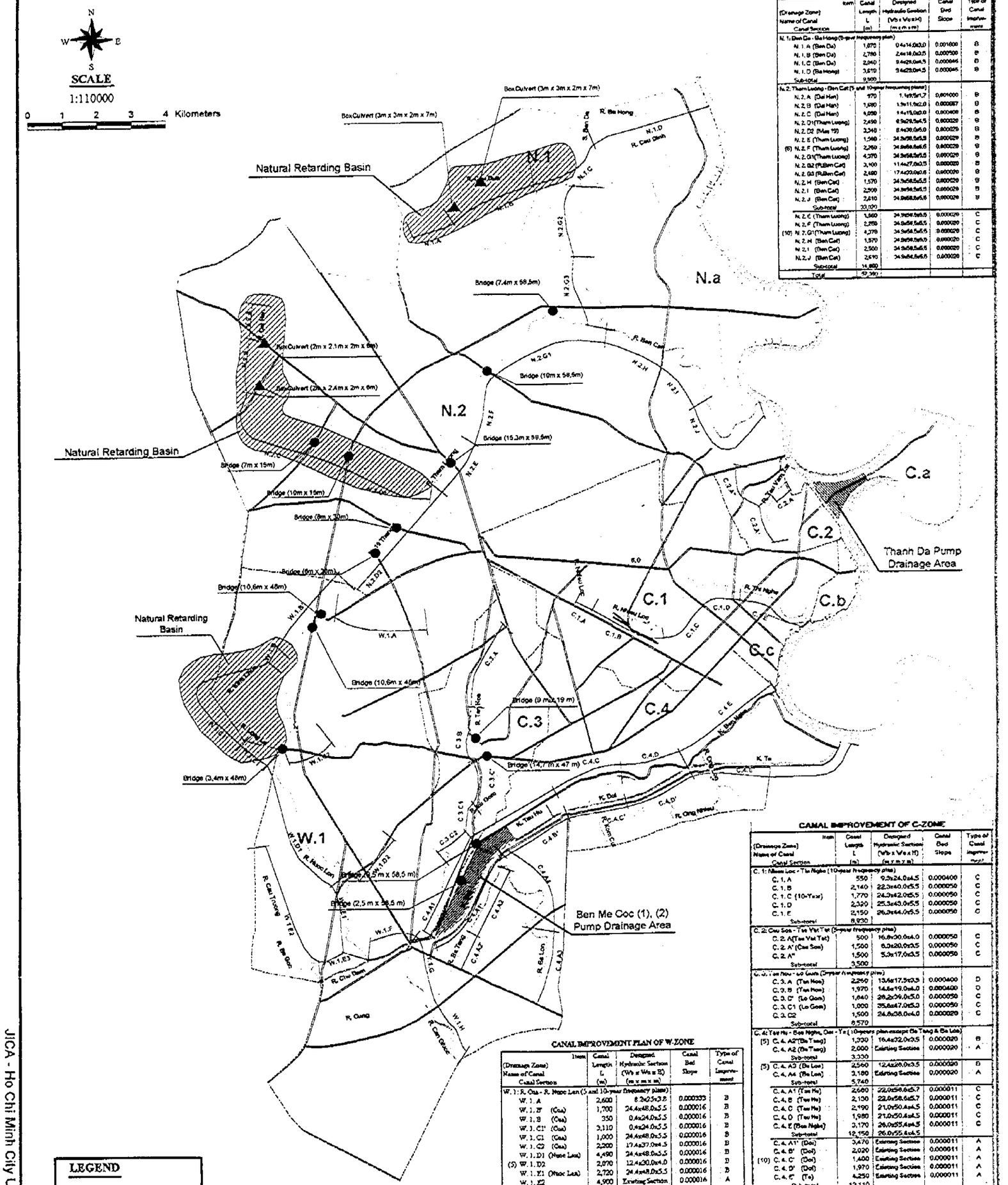


FIG. 6.10 TYPICAL CROSS SECTION OF PROPOSED CANAL IMPROVEMENT



CANAL IMPROVEMENT PLAN OF N-ZONE

Item (Drainage Zone) Name of Canal / Canal Section	Canal Length L (m)	Designed Hydraulic Section (Wb x Wa x H) (m x m x m)	Canal Bed Slope	Type of Canal Improvement
N. 1: Ben Da - Ba Hong (5-year frequency plan)				
N. 1. A (Ben Da)	1,670	0.4x14.0x3.0	0.001600	B
N. 1. B (Ben Da)	2,780	2.4x18.0x3.5	0.000500	B
N. 1. C (Ben Da)	2,940	9.4x29.0x4.5	0.000046	B
N. 1. D (Ba Hong)	3,610	9.4x29.0x4.5	0.000046	B
Sub-total	9,900			
N. 2: Thanh Luong - Ben Cat (5- and 10-year frequency plans)				
N. 2. A (Dai Han)	970	1.1x9.5x1.7	0.001000	B
N. 2. B (Dai Han)	1,680	1.5x11.0x2.0	0.000857	B
N. 2. C (Dai Han)	4,050	1.4x15.0x3.0	0.000408	B
N. 2. D1 (Thanh Luong)	2,490	6.5x29.5x4.5	0.000029	B
N. 2. D2 (Mau 19)	3,340	8.4x30.0x5.0	0.000029	B
N. 2. E (Thanh Luong)	1,540	34.5x58.5x5.5	0.000029	B
(6) N. 2. F (Thanh Luong)	2,260	34.5x58.5x5.5	0.000029	B
N. 2. G1 (Thanh Luong)	4,370	34.5x58.5x5.5	0.000029	B
N. 2. G2 (Rubin Cat)	3,100	11.4x27.0x3.5	0.000029	B
N. 2. G3 (Rubin Cat)	2,480	17.4x27.0x5.5	0.000029	B
N. 2. H (Ben Cat)	1,570	34.5x58.5x5.5	0.000029	B
N. 2. I (Ben Cat)	2,500	34.5x58.5x5.5	0.000029	B
N. 2. J (Ben Cat)	2,610	34.5x58.5x5.5	0.000029	B
Sub-total	33,100			
N. 2. E (Thanh Luong)	1,560	34.5x58.5x5.5	0.000029	C
N. 2. F (Thanh Luong)	2,260	34.5x58.5x5.5	0.000029	C
(10) N. 2. G1 (Thanh Luong)	4,370	34.5x58.5x5.5	0.000029	C
N. 2. H (Ben Cat)	1,570	34.5x58.5x5.5	0.000029	C
N. 2. I (Ben Cat)	2,500	34.5x58.5x5.5	0.000029	C
N. 2. J (Ben Cat)	2,610	34.5x58.5x5.5	0.000029	C
Sub-total	14,800			
Total	47,900			

CANAL IMPROVEMENT OF C-ZONE

Item (Drainage Zone) Name of Canal / Canal Section	Canal Length L (m)	Designed Hydraulic Sections (Wb x Wa x H) (m x m x m)	Canal Bed Slope	Type of Canal Improvement
C. 1: Nhieu Loc - Tle Nghe (10-year frequency plan)				
C. 1. A	550	9.5x24.0x4.5	0.000400	C
C. 1. B	2,140	22.3x40.0x5.5	0.000050	C
C. 1. C (10-Year)	1,770	24.3x42.0x5.5	0.000050	C
C. 1. D	2,320	25.3x43.0x5.5	0.000050	C
C. 1. E	2,150	26.3x44.0x5.5	0.000050	C
Sub-total	8,930			
C. 2: Cau Soa - Tle Viet Tiet (5-year frequency plan)				
C. 2. A(Tau Viet Tiet)	500	16.8x30.0x4.0	0.000050	C
C. 2. A' (Cau Soa)	1,500	6.0x20.0x3.5	0.000050	C
C. 2. A"	1,500	5.0x17.0x3.5	0.000050	C
Sub-total	3,500			
C. 3: Tau Hou - Lo Gom (5-year frequency plan)				
C. 3. A (Tau Hou)	2,290	13.6x17.5x3.5	0.000400	D
C. 3. B (Tau Hou)	1,970	14.6x19.0x4.0	0.000400	D
C. 3. C' (Lo Gom)	1,640	28.2x39.0x5.0	0.000050	C
C. 3. C1 (Lo Gom)	1,000	35.6x47.0x5.0	0.000050	C
C. 3. C2	1,500	24.6x36.0x4.0	0.000020	C
Sub-total	8,570			
C. 4: Tau Hu - Bau Nghe, Cau - Te (10-years plan except Ba Trang & Ba Lon)				
(5) C. 4. A2" (Ba Trang)	1,330	16.4x32.0x3.5	0.000020	B
C. 4. A2 (Ba Trang)	2,000	Existing Section	0.000020	A
Sub-total	3,330			
(5) C. 4. A3' (Ba Lon)	2,560	12.4x26.0x3.5	0.000020	B
C. 4. A4 (Ba Lon)	3,180	Existing Section	0.000020	A
Sub-total	5,740			
C. 4. A1' (Tau Hu)	2,680	22.0x58.6x5.7	0.000011	C
C. 4. B (Tau Hu)	2,150	22.0x58.6x5.7	0.000011	C
C. 4. C (Tau Hu)	2,190	21.0x50.4x4.5	0.000011	C
C. 4. D (Tau Hu)	1,980	21.0x50.4x4.5	0.000011	C
C. 4. E (Bau Nghe)	3,170	26.0x55.4x4.5	0.000011	C
Sub-total	12,150	26.0x55.4x4.5		
C. 4. A1' (Dai)	3,470	Existing Section	0.000011	A
C. 4. B' (Doi)	2,020	Existing Section	0.000011	A
(10) C. 4. C' (Doi)	1,400	Existing Section	0.000011	A
C. 4. D' (Doi)	1,970	Existing Section	0.000011	A
C. 4. E' (Te)	4,250	Existing Section	0.000011	A
Sub-total	13,110			
Sub-total	34,930			
Total	55,330			

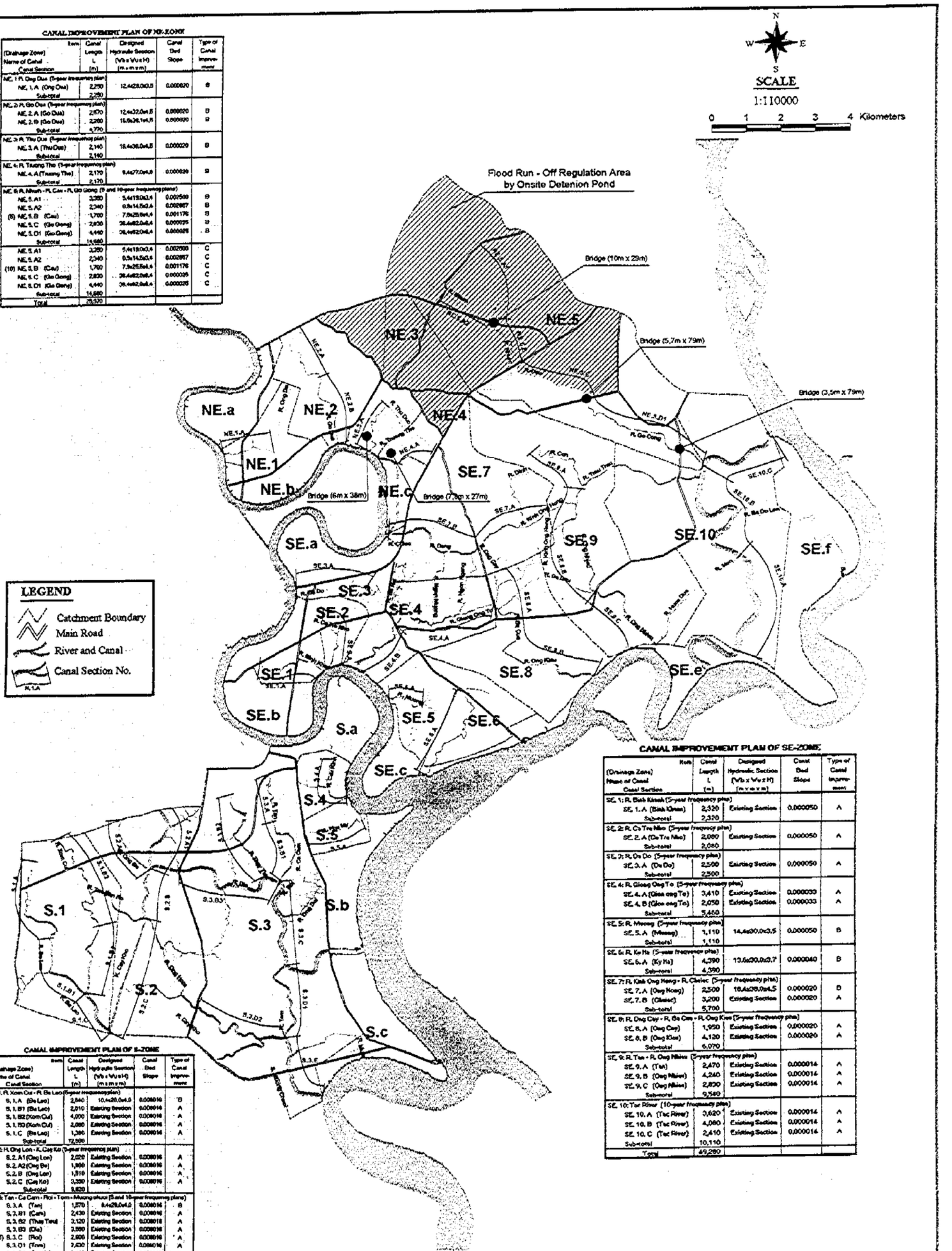
CANAL IMPROVEMENT PLAN OF W-ZONE

Item (Drainage Zone) Name of Canal / Canal Section	Canal Length L (m)	Designed Hydraulic Section (Wb x Wa x H) (m x m x m)	Canal Bed Slope	Type of Canal Improvement
W. 1: R. Cau - R. Nuoc Lan (5 and 10-year frequency plans)				
W. 1. A	2,600	8.2x25x3.8	0.000333	B
W. 1. B' (Cau)	1,700	24.4x48.0x5.5	0.000016	B
W. 1. B (Cau)	350	0.4x24.0x5.5	0.000016	B
W. 1. C1' (Cau)	3,110	0.4x24.0x5.5	0.000016	B
W. 1. C1 (Cau)	1,000	24.4x48.0x5.5	0.000016	B
W. 1. C2 (Cau)	2,200	17.4x37.0x4.5	0.000016	B
W. 1. D1 (Nuoc Lan)	4,490	24.4x48.0x5.5	0.000016	B
(5) W. 1. D2	2,070	12.4x30.0x4.0	0.000016	B
W. 1. E1 (Nuoc Lan)	2,720	24.4x48.0x5.5	0.000016	B
W. 1. E2	4,900	Existing Section	0.000016	A
W. 1. E3 (Ben Luc)	1,360	Existing Section	0.000016	A
W. 1. F (Ben Luc)	1,180	Existing Section	0.000016	A
W. 1. G (Can Guoc)	1,850	Existing Section	0.000016	A
W. 1. H (Can Guoc)	1,850	Existing Section	0.000016	A
Sub-total	31,390			
W. 1. B' (Cau)	1,700	24.4x48.0x5.5	0.000016	C
W. 1. C1 (Cau)	1,000	24.4x48.0x5.5	0.000016	C
W. 1. D1 (Nuoc Lan)	4,490	24.4x48.0x5.5	0.000016	C
(10) W. 1. E1 (Nuoc Lan)	2,720	24.4x48.0x5.5	0.000016	C
W. 1. F (Ben Luc)	1,180	Existing Section	0.000016	A
W. 1. G (Can Guoc)	1,850	Existing Section	0.000016	A
W. 1. H (Can Guoc)	1,850	Existing Section	0.000016	A
Sub-total	14,790			
Total	46,180			

FIG. 6.11(1/2) PROPOSED CANAL IMPROVEMENT PLAN FOR C, N AND W - ZONE

CANAL IMPROVEMENT PLAN OF NE-ZONE

(Drainage Zone) Name of Canal / Canal Section	Item	Canal Length L (m)	Designed Hydraulic Section (Wb x Wu x H) (m x m x m)	Canal Bed Slope	Type of Canal Improvement
NE. 1 R. Ong Dua (5-year frequency plan)					
NE. 1. A (Ong Dua)		2,250	12.4x23.0x3.5	0.000020	B
Sub-total		2,250			
NE. 2 R. Go Dua (5-year frequency plan)					
NE. 2. A (Go Dua)		2,570	12.4x32.0x4.5	0.000020	B
NE. 2. B (Go Dua)		2,200	15.0x36.1x4.5	0.000020	B
Sub-total		4,770			
NE. 3 R. Thu Dua (5-year frequency plan)					
NE. 3. A (Thu Dua)		2,140	18.4x36.0x4.5	0.000020	B
Sub-total		2,140			
NE. 4 R. Truong Tho (5-year frequency plan)					
NE. 4. A (Truong Tho)		2,170	9.4x27.0x4.0	0.000020	B
Sub-total		2,170			
NE. 5 R. Nhuan - R. Cau - R. Go Gong (5 and 10-year frequency plans)					
NE. 5. A1		3,350	5.4x13.0x3.5	0.002500	B
NE. 5. A2		2,340	9.9x14.5x3.5	0.002857	B
(5) NE. 5. B (Cau)		1,700	7.9x25.8x4.5	0.001176	B
NE. 5. C (Go Gong)		2,830	28.4x62.0x8.5	0.000025	B
NE. 5. D1 (Go Gong)		4,440	28.4x62.0x8.5	0.000025	B
Sub-total		14,660			
NE. 5. A1		3,350	5.4x13.0x3.5	0.002500	C
NE. 5. A2		2,340	9.9x14.5x3.5	0.002857	C
(10) NE. 5. B (Cau)		1,700	7.9x25.8x4.5	0.001176	C
NE. 5. C (Go Gong)		2,830	28.4x62.0x8.5	0.000025	C
NE. 5. D1 (Go Gong)		4,440	28.4x62.0x8.5	0.000025	C
Sub-total		14,660			
Total		29,970			



CANAL IMPROVEMENT PLAN OF SE-ZONE

(Drainage Zone) Name of Canal / Canal Section	Item	Canal Length L (m)	Designed Hydraulic Section (Wb x Wu x H) (m x m x m)	Canal Bed Slope	Type of Canal Improvement
SE. 1: R. Binh Khanh (5-year frequency plan)					
SE. 1. A (Binh Khanh)		2,320	Existing Section	0.000050	A
Sub-total		2,320			
SE. 2: R. Da Tre Nho (5-year frequency plan)					
SE. 2. A (Da Tre Nho)		2,080	Existing Section	0.000050	A
Sub-total		2,080			
SE. 3: R. Da Do (5-year frequency plan)					
SE. 3. A (Da Do)		2,500	Existing Section	0.000050	A
Sub-total		2,500			
SE. 4: R. Giong Ong To (5-year frequency plan)					
SE. 4. A (Giong ong To)		3,410	Existing Section	0.000033	A
SE. 4. B (Giong ong To)		2,050	Existing Section	0.000033	A
Sub-total		5,460			
SE. 5: R. Muong (5-year frequency plan)					
SE. 5. A (Muong)		1,110	14.4x30.0x3.5	0.000050	B
Sub-total		1,110			
SE. 6: R. Ke Ha (5-year frequency plan)					
SE. 6. A (Ky Ha)		4,390	10.6x30.0x3.7	0.000040	B
Sub-total		4,390			
SE. 7: R. Kinh Ong Hoang - R. Chalec (5-year frequency plan)					
SE. 7. A (Ong Hoang)		2,500	18.4x36.0x4.5	0.000020	B
SE. 7. B (Chalec)		3,200	Existing Section	0.000020	A
Sub-total		5,700			
SE. 8: R. Ong Cay - R. Ba Cau - R. Ong Kiew (5-year frequency plan)					
SE. 8. A (Ong Cay)		1,950	Existing Section	0.000020	A
SE. 8. B (Ong Kiew)		4,120	Existing Section	0.000020	A
Sub-total		6,070			
SE. 9: R. Tan - R. Ong Nhieu (5-year frequency plan)					
SE. 9. A (Tan)		2,470	Existing Section	0.000014	A
SE. 9. B (Ong Nhieu)		4,240	Existing Section	0.000014	A
SE. 9. C (Ong Nhieu)		2,830	Existing Section	0.000014	A
Sub-total		9,540			
SE. 10: Tac River (10-year frequency plan)					
SE. 10. A (Tac River)		3,620	Existing Section	0.000014	A
SE. 10. B (Tac River)		4,080	Existing Section	0.000014	A
SE. 10. C (Tac River)		2,410	Existing Section	0.000014	A
Sub-total		10,110			
Total		49,280			

CANAL IMPROVEMENT PLAN OF S-ZONE

(Drainage Zone) Name of Canal / Canal Section	Item	Canal Length L (m)	Designed Hydraulic Section (Wb x Wu x H) (m x m x m)	Canal Bed Slope	Type of Canal Improvement
S. 1: R. Xom Cui - R. Ba Lao (5-year frequency plan)					
S. 1. A (Ba Lao)		2,840	10.4x28.0x4.0	0.000616	B
S. 1. B1 (Ba Lao)		2,010	Existing Section	0.000616	A
S. 1. B2 (Xom Cui)		4,000	Existing Section	0.000616	A
S. 1. B3 (Xom Cui)		2,680	Existing Section	0.000616	A
S. 1. C (Ba Lao)		1,390	Existing Section	0.000616	A
Sub-total		12,920			
S. 2: R. Ong Lon - R. Cay Ke (5-year frequency plan)					
S. 2. A1 (Ong Lon)		2,020	Existing Section	0.000616	A
S. 2. A2 (Cay Be)		1,800	Existing Section	0.000616	A
S. 2. B (Ong Lon)		1,810	Existing Section	0.000616	A
S. 2. C (Cay Ke)		3,390	Existing Section	0.000616	A
Sub-total		9,020			
S. 3: Tan - Cai Cam - Rot - Tom - Muong chuot (5 and 10-year frequency plans)					
S. 3. A (Tan)		1,870	8.4x28.0x4.0	0.000616	B
S. 3. B1 (Cam)		2,430	Existing Section	0.000616	A
S. 3. B2 (Thap Tieu)		3,120	Existing Section	0.000616	A
S. 3. B3 (Da)		3,880	Existing Section	0.000616	A
(5) S. 3. C (Rot)		2,600	Existing Section	0.000616	A
S. 3. D1 (Tom)		2,430	Existing Section	0.000616	A
S. 3. D2 (Cay Ke)		3,410	Existing Section	0.000616	A
S. 3. E (Muong Chuot)		2,410	Existing Section	0.000616	A
Sub-total		21,750			
S. 3. A (Tan)		1,870	8.4x28.0x4.0	0.000616	B
S. 3. B1 (Cam)		2,430	Existing Section	0.000616	A
(10) S. 3. C (Rot)		2,600	Existing Section	0.000616	A
S. 3. D1 (Tom)		2,830	Existing Section	0.000616	A
S. 3. E (Muong Chuot)		2,410	Existing Section	0.000616	A
Sub-total		11,640			
S. 4: R. Cau Kinh (5-year frequency plan)					
S. 4. A (Cau Kinh)		1,920	Existing Section	0.000020	A
Sub-total		1,920			
S. 5: R. AP3Phu My (5-year frequency plan)					
S. 5. A (AP3Phu My)		1,950	Existing Section	0.000020	A
Sub-total		1,950			
Total		58,490			

FIG. 6.11(2/2)PROPOSED CANAL IMPROVEMENT PLAN FOR S, NE AND SE - ZONE

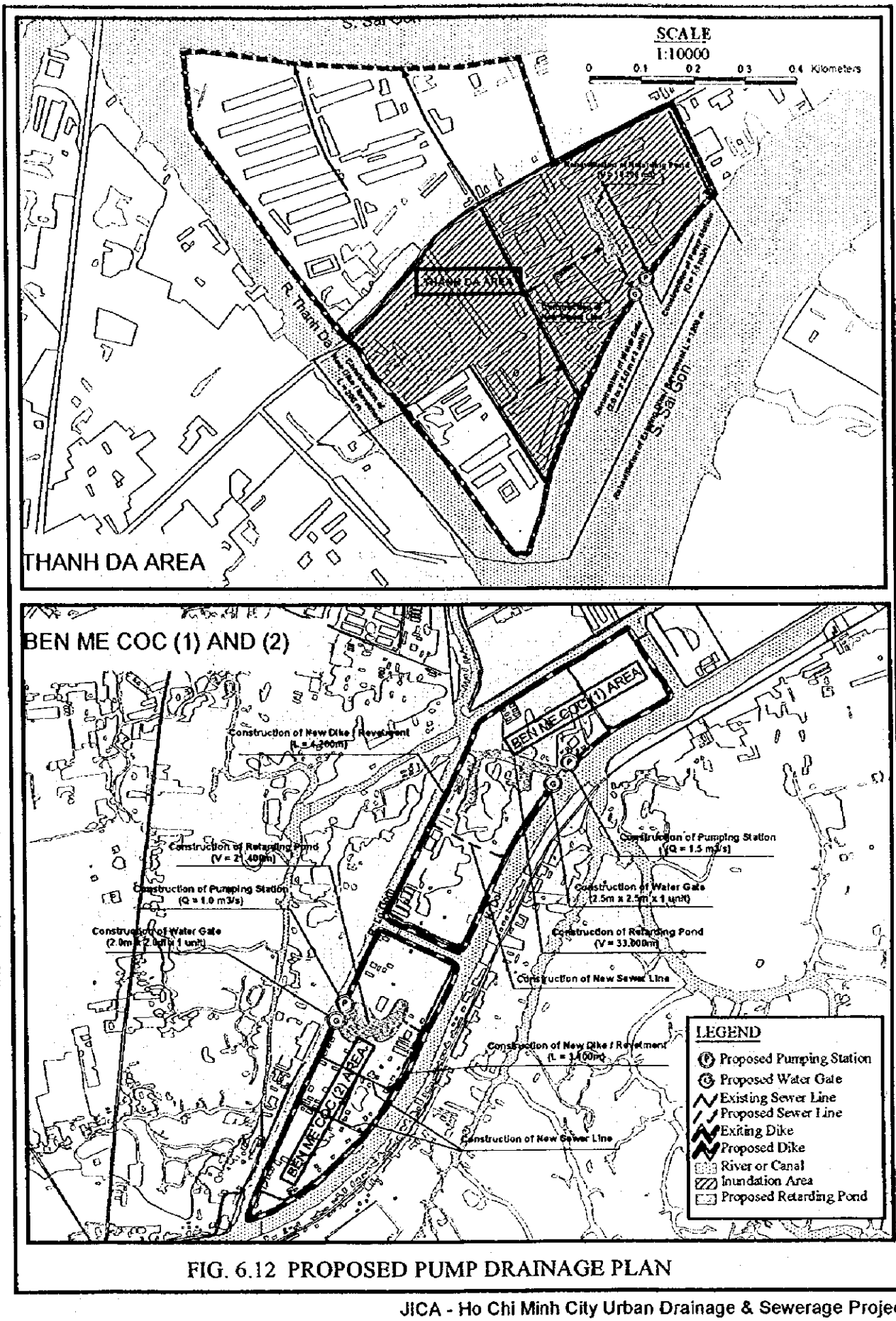


FIG. 6.12 PROPOSED PUMP DRAINAGE PLAN

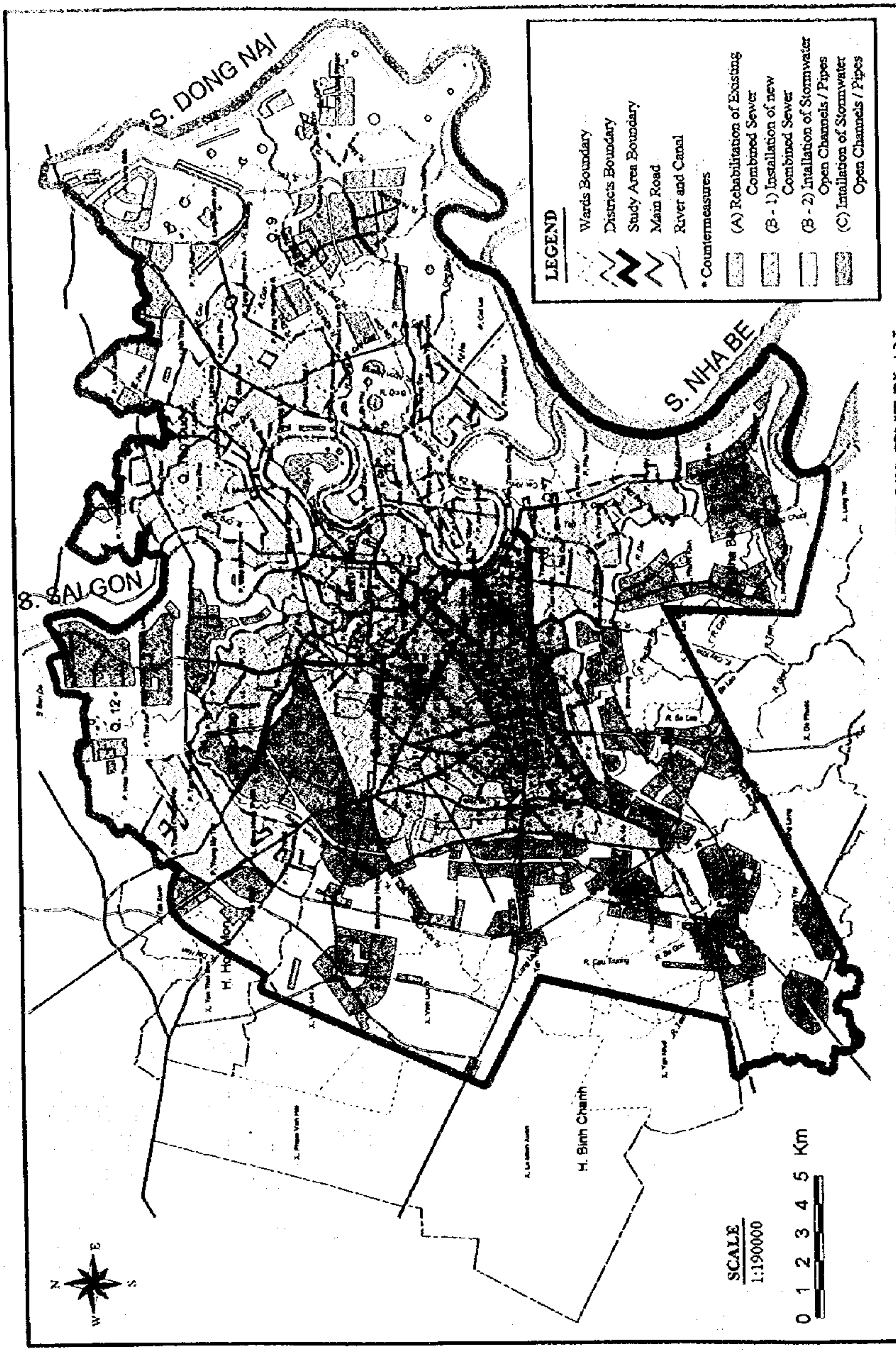


FIG. 6.13 DRAINAGE PIPE/CHANNEL SYSTEM DEVELOPMENT PLAN

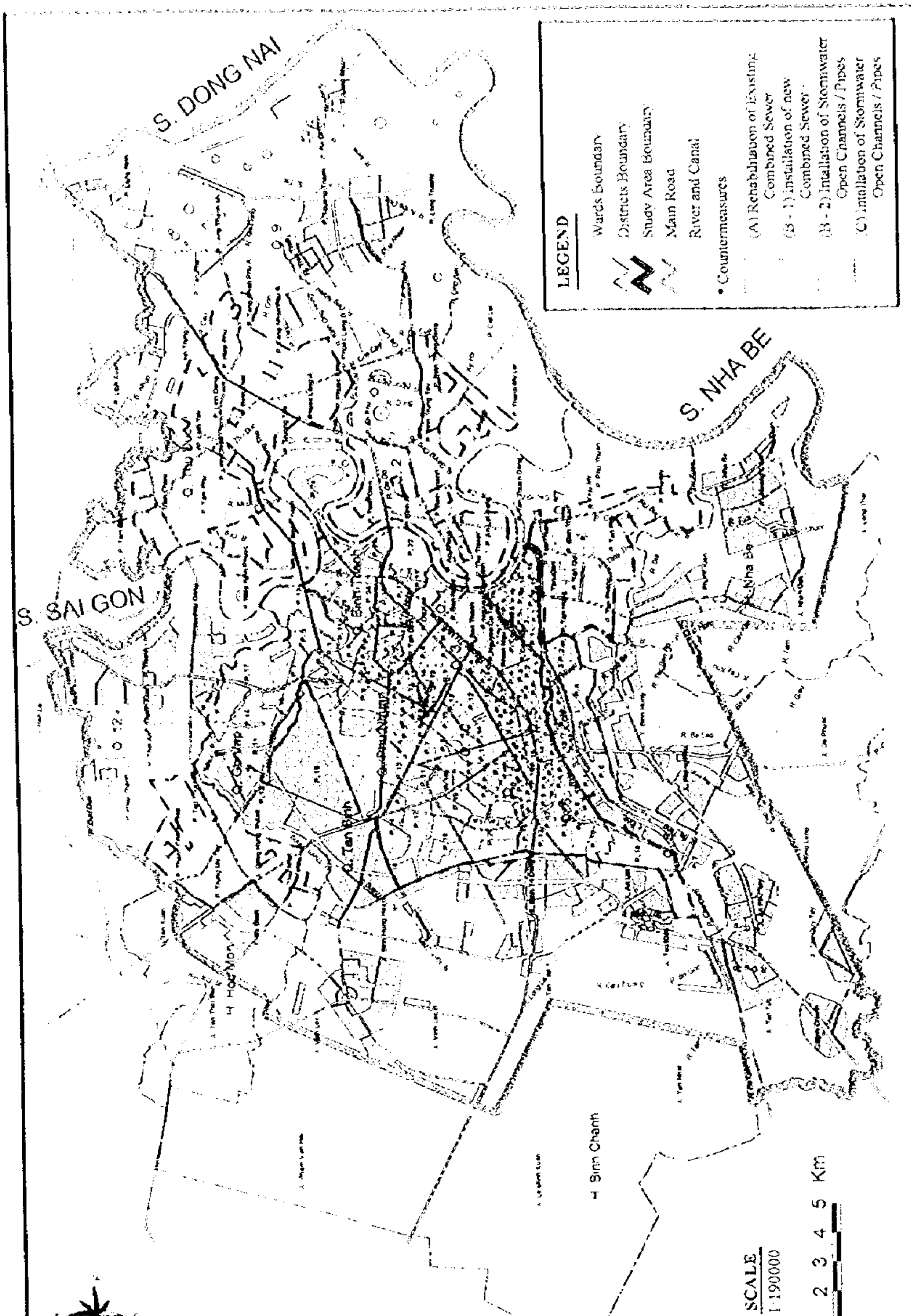


FIG. 6.13 DRAINAGE PIPE/CHANNEL SYSTEM DEVELOPMENT PLAN

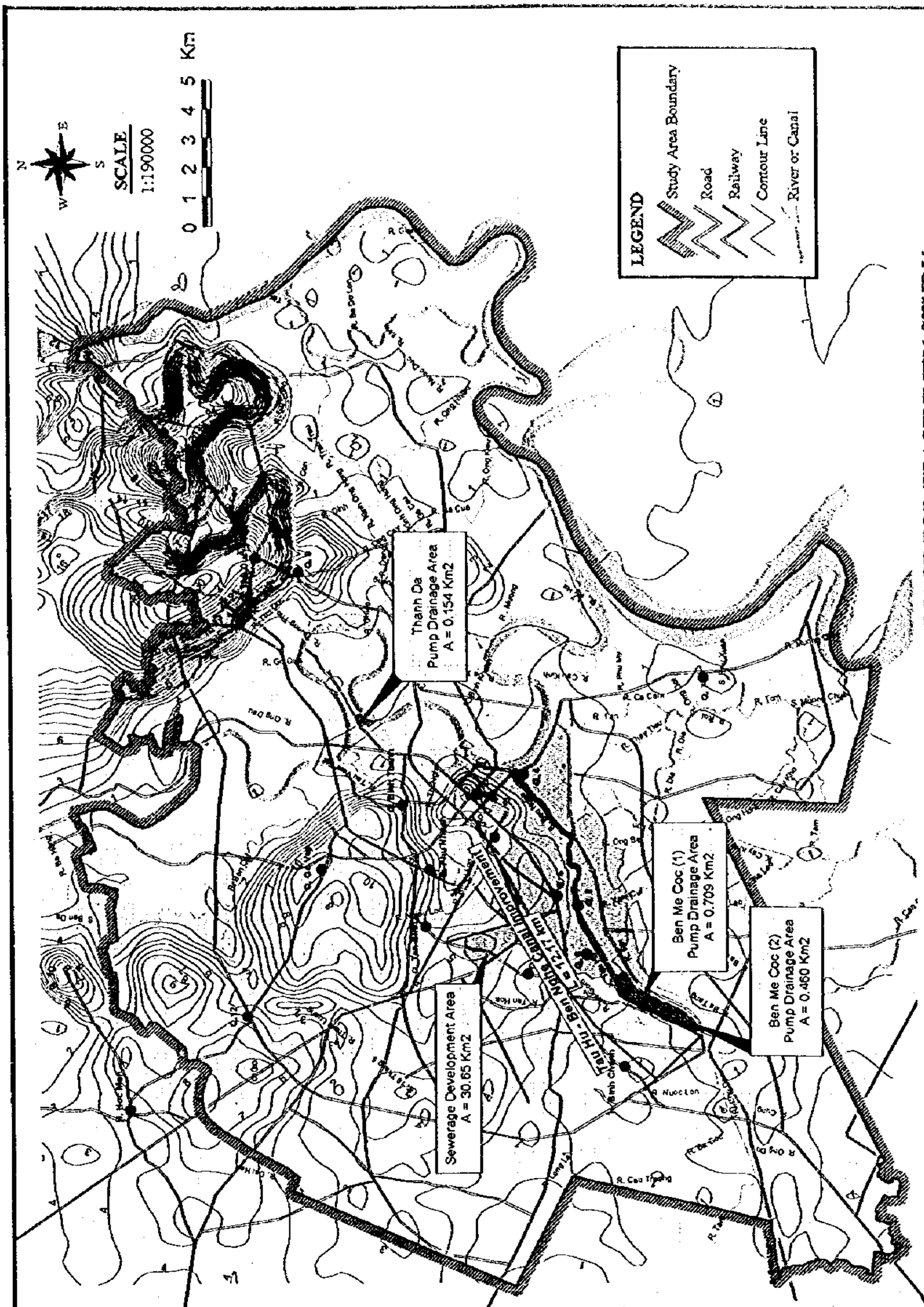


FIG. 6.14 PRIORITY PROJECT OF URBAN DRAINAGE FOR FEASIBILITY STUDY

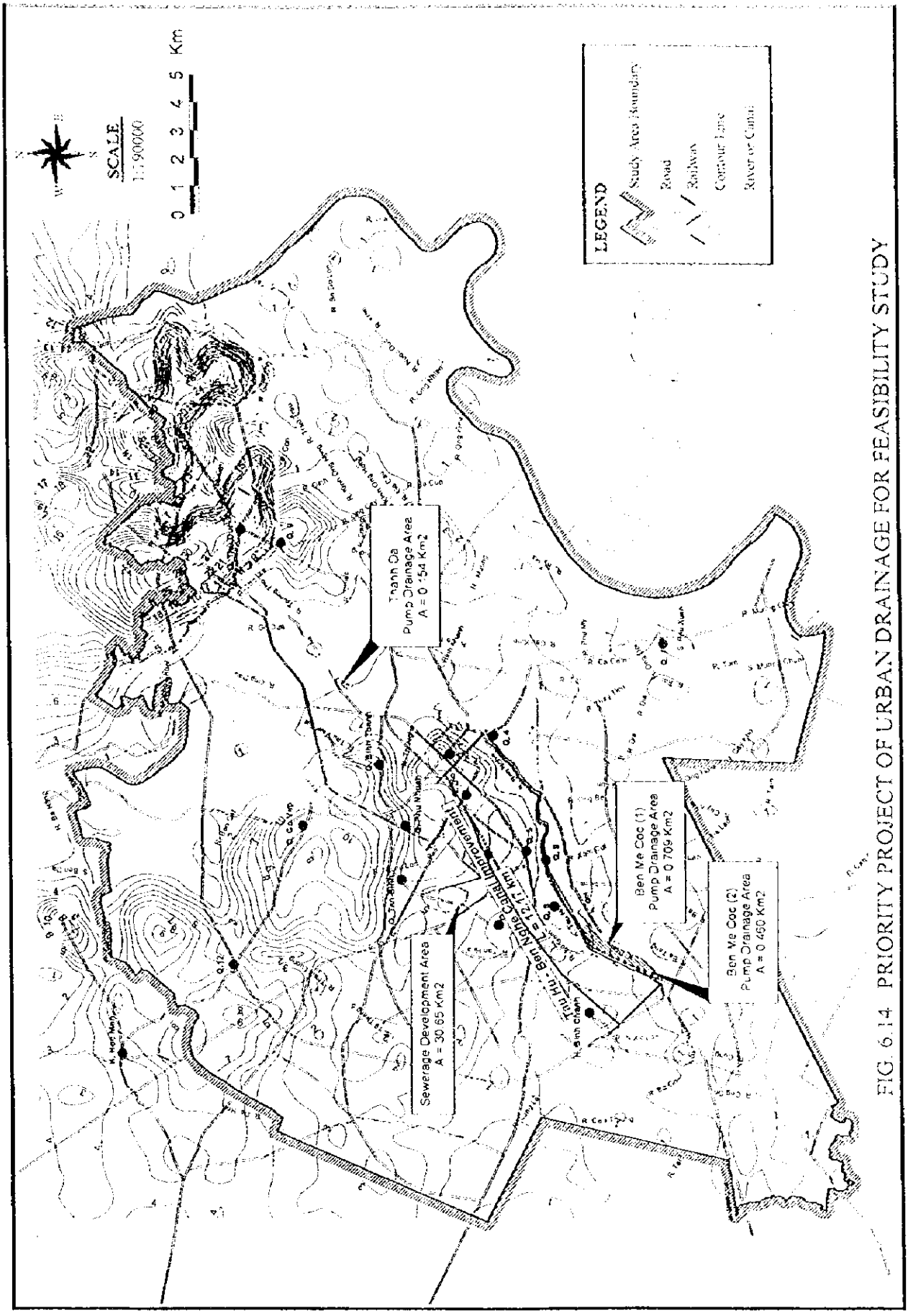


FIG 6.14 PRIORITY PROJECT OF URBAN DRAINAGE FOR FEASIBILITY STUDY

CHAPTER 7

MASTER PLAN OF SEWERAGE DEVELOPMENT

CHAPTER 7 MASTER PLAN OF SEWERAGE DEVELOPMENT

7.1 Fundamentals of Planning Framework

7.1.1 Target Year

To formulate a Master Plan for the development of an economically viable sewerage system, the elements of work necessary are forecasted and defined in successive stages to meet the present and future needs of the study area up to the year 2020. The Master Plan has been prepared, which is compatible with sound projections of population increase, water consumption, income growth, socio-economic factors, development programs and on-going projects in Ho Chi Minh City.

7.1.2 Identification of Sewerage and Sanitation Area

To identify the areas, which can be covered by sanitation system more economically, a comparative study was conducted. Details are mentioned in Supporting Report Appendix F. Sanitation system is more economical than sewerage system for the area having population density less than 200 person/ha. Keeping this in mind, sewerage development area is delineated based on the following criteria.

(a) Wards with a population density of more than 200 person/ha will be included in the sewerage development area, in principle. However, wards in which the locations are isolated from other high population density areas, separated by canals and main roads and wards where large industrial developments are expected, will be excluded.

(b) Wards in the newly developed districts, especially in District Thu Duc, District 9, 2 and 12, their net population density, which is population divided by inhabitable area, is more than 200 person/ha will also be included in the sewerage development area. Such wards are:

District Thu Duc:	Binh Chieu, Tam Phu, Binh Thoi, Hiep Binh chanh, Hiep Binh Phuoc, Linh Chieu, Linh dong, Linh Tay, Linh Trung, Tam Binh, Tam Phu, and Truong Tho
District 9:	Hiep Phu, Tang Nhon Phu A, Tang Nhon Phu B, Phuoc Binh, phuoc Long A, and Phuoc Long B
District 2:	Thao Dien, Binh Trung Dong, Binh Trung Tay, Cat Lai, and Thanh My Loi
District 12:	Hiep Thanh, Tan Thoi Hiep, Tan Thoi Nhat, Tan chanh Hiep, Trung My tay, and Dong Hung Thuan

(c) Wards surrounded by or located in the vicinity of other high population density areas and wards in which the combined sewer is already installed will also be included even though their population density is lower than 200 person/ha. Such wards are:

Ben Nghe in D.1, Ward 6 in D.3, Wards 1 and 18 in D. 4, Wards 11, 12 in D. 5, Ward 10 in D. 6, Tan Thuan in D. 7, Ward 5 in D. 8, wards 12 and 14 in D. 10, Ward 9 in D. Phu Nhuan, Wards 2, 4, 12, 14, 16, 19, 20 in D. Tan Binh, Wards 13, 22 in D. Binh Thanh, and Ward 5 in D. Go Vap.

Districts/wards to be served by sewerage and on-site sanitation system are shown in Fig. 7.1.

7.1.3 Planned Population

Population to be served by sewerage and sanitation system is shown in Table 7.1. In the year 2020, 189.78 km^2 of area (30 % of the study area) and 5,774,748 population (78 % of the study area) is planned to be served by sewerage system.

7.1.4 Unit Per Capita Wastewater Generation

Wastewater generation in a city is related to the water consumption. Based on the previous study of Master Plan on Sewerage System & Urban Sanitation in Ho Chi Minh City (2010 - 2020) prepared by UPI, unit per capita water consumption in the study area is estimated and is shown below.

Area	Unit Water Consumption	
	Year 1997	Year 2020
Inner City Area	175 l/c/d	345 l/c/d
New Urbanized Area	145 l/c/d	263 l/c/d
Suburban Area	95 l/c/d	145 l/c/d

Water consumption in the industrial estate is estimated to be 60 m^3/ha/d in 1997 and 80 m^3/ha/d in 2020.

Wastewater Generation is estimated based on the following assumptions:

(a) Wastewater generation is estimated by adding wastewater from domestic, public services and small industries. Wastewater from major industries/industrial zones should be treated before discharging to public water bodies and is not included in the scope of this study.

(b) Water consumed will result in generation of wastewater except that consumed for watering plants.

(c) Ground water infiltration is assumed at 10 % of daily average wastewater discharge.

Based on these assumptions unit per capita wastewater generation is estimated as shown below.

Area	Unit Wastewater Generation	
	Year 1997	Year 2020
Inner City Area	170 l/c/d	335 l/c/d
New Urbanized Area	140 l/c/d	253 l/c/d
Suburban Area	90 l/c/d	135 l/c/d

Existing and future total wastewater generation in 2020 is estimated to be 711,370 m^3/day and 2,071,050 m^3/day, respectively. Existing and future wastewater generations by each district are shown in Table 7.1.

7.1.5 Pollution Load Generation and Wastewater Quality

Based on the study conducted in other tropical countries, unit pollution load generation in terms of BOD_5 is assumed as mentioned below.

Area	Unit Pollution Load (BOD_5)	
	Year 1997	Year 2020
Inner City Area	40 g/c/d	60 g/c/d
New Urbanized Area	35 g/c/d	45 g/c/d
Suburban Area	25 g/c/d	35 g/c/d

Pollution load discharged from public services is assumed to be included in the domestic unit pollution load.

Existing and future pollution load generation as BOD_5 from domestic and public services in the study area are estimated to be 169,650 kg/day and 382,790 kg/day, respectively. Existing and future domestic pollution load that will be generated in the study area is shown in Table 7.2. Based on the unit pollution load generation, wastewater quality in terms of BOD_5 is assumed to be 180 - 250 mg/l.

7.1.6 Treatment Level Required

Vietnamese Standard TCVN 5945 - 1995 regulates the concentration of pollutants in

the effluent of industrial wastewater which is to be discharged to water bodies based on the potential usage of water body. If water body is being used for domestic water supply then BOD_5 should not be more than 20 mg/l, however for other uses maximum allowed BOD_5 is 50 mg/l. The Master plan is being prepared for the year 2020, to conserve water environment, effluent is recommended to have BOD_5 of the order of 20 mg/l. Hence secondary treatment of wastewater is required.

7.1.7 Wastewater Treatment Plant Locations

(1) Concept of Site Selection

The site should ideally:

(a) be located where the wastewater from service area could be collected mostly by gravity.
(b) have sufficient area available for the proposed treatment facilities and be located where land owner(s) and neighboring residents agree to the plant construction.
(c) be located close to the receiving water for discharging the treated effluent to minimize the outfall cost.
(d) be sighted in a scarcely populated area with least adverse environmental impact.
(e) be located in green area and open space of future land use plan.
(f) have easy access for construction and O/M of the plant.

(2) Potential Identified Sites

With due consideration to the above-mentioned criteria, treatment plant sites identified by various previous studies are carefully examined. After site reconnaissance and discussions with concerned authorities, the potential treatment plant sites are identified as shown in Fig. 7.2. The details of these sites are summarized in Table 7.3.

7.2 Sewerage Development Plan

The sewerage development plan for the year 2020 covers 18,978 ha which includes inner city area and newly developed districts of Thu Duc, District 2, 7, 9 and 12. Sewerage plan has been developed based on the following characteristics of the study area.

(a) Development area is divided into two zones of West and East by Saigon river

(b) West zone consists of inner city area and newly developed districts of 12 and 7 and East zone consists of newly developed districts of Thu Duc, 2 and 9.

(c) Inner city area has combined sewer system already existing, which covers about 50 % of the objective sewerage area. Newly developed area has no sewerage system.

(d) Several projects are on going in the study area. These projects have been formulated for individual canal system covering catchment area of that particular canal.

7.2.1 Alternative Study

Wastewater discharge in combined sewer area is collected and treated at one site and the eastern part of Saigon River is also integrated and wastewater is treated at respective treatment plant site. The remaining wastewater will be treated at individual small-scale treatment plant. This concept is referred as Collective Treatment in this Report. The other alternative is to divide whole sewerage area into several zones and collect and treat wastewater at individual zone. The sewerage area is divided into nine (9) zones based on the characteristics of the study area as discussed above and details of these zones are shown below.

Zone	District
Tham Long – Ben Cat (TLBC)	Binh Thanh, Go Vap
Nhieu Loc – Thi Nghe (NLTN)	1, 3, 10, Binh Thanh, Go Vap, Phu Nhuan, Tan Binh
Tan Hoa – Lo Gom (THLG)	6, 8, 11, Tan Binh
Tau Hu – Ben Nghe – Doi – Te (THBNDT)	1, 3, 4, 5, 6, 8, 10, 11, Tan Binh
Saigon West (SW)	12
Saigon South (SS)	7
Saigon North I (SN-I)	Thu Duc
Saigon North II (SN-II)	9
Saigon East (SE)	2

The two alternatives compared for sewerage development are as follows:

(1) Alternative 1 - Individual Treatment System

Sewerage zone is divided into above-mentioned nine (9) zones and wastewater is treated by individual treatment plant. Details of Alternative 1 are mentioned below. Fig. 7.3 shows the details of Alternative 1.

Item	Details	Remarks
Interceptor Sewer	ϕ 500 - 2,500 mm, length 92,444 m	Inner City Area
Conveyance Sewer	ϕ 1600 - 3,000 mm, length 19,726 m	Inner City Area
Secondary & Tertiary	ϕ 150 - 500 mm, length 372,432 m	Newly Developed Area
Main Sewer	ϕ 600 - 1,300 mm, length 858,350 m	Newly Developed Area
Conveyance Sewer	ϕ 1,100 mm, length 2,899 m	Newly Developed Area
Treatment Plant	9, Activated Sludge Process	Whole Sewerage Area

(2) Alternative 2 - Collective Treatment System

Four sewerage zones namely TLBC, NLTN, THLG and THBNDT in the inner city where wastewater is collected by combined system are integrated into one sewerage system so as to treat collectively at one site. Three sewerage zones SN-I, SN-II and SE are integrated into one sewerage system. Remaining two zones SW and SS, which lie in the newly developed area, are planned to have individual treatment system. Details of Alternative 2 are mentioned below and are shown in Fig. 7.4.

Item	Details	Remarks
Secondary & Tertiary	ϕ 150 - 500 mm, length 372,432 m	Newly Developed Area
Main Sewer	ϕ 500 - 1,400 mm, length 858,350 m	Newly Developed Area
Interceptor Sewer	ϕ 500 - 4,500 mm, length 103,705 m	
Conveyance Sewer	ϕ 4,500 mm, length 4,612 m	
Treatment Plant	4, Activated Sludge Process	Whole Sewerage Area

The details of two alternatives are shown in Supporting Report Appendix F, Section 5. The construction cost and operation & maintenance cost of these two alternatives are compared below.

Alternative	Construction Cost (Billion VND)	Annual O&M Cost (Billion VND)
Alternative 1: Individual Treatment System	21,713.8	137.8
Alternative 2: Collective Treatment System	23,307.2	146.0

The construction cost and O/M cost of Individual Treatment System is lower than Collective Treatment System and hence is recommended as sewerage development plan.

7.2.2 Proposed Plan

Individual Treatment System will be applied for the planning of sewerage system in the

study area. Sewerage area of 18,978 ha is proposed to be developed into nine (9) sewerage zones. The details of these zones are shown in the previous section. Each zone will have its own collection and treatment system before discharging wastewater to the water bodies. The details are discussed in section 7.6.

7.3 Wastewater Collection System

7.3.1 Strategy for Wastewater Collection

The separate system in which only wastewater is received and not the storm water runoff has following technical, environmental and economical merits.

(a) Separate system has less possibility of pollutants getting accumulated in the pipe than combined system

(b) When it rains, the combined system causes pollution in the receiving water due to the overflow of untreated wastewater

(c) Only separate system can keep sanitary wastes out of rivers and storm drains and can reduce pollution of surface water bodies

(d) In separate system storm water can be drained by ditches and/or small canals directly which proves more economical than combined system.

However about 5,331 ha of the inner city has already combined system existing, hence combined system is recommended in the inner city area. The area of inner city with no combined system will be proposed to have system consisting of main, secondary and tertiary sewers. The interceptor sewer will be installed along the rivers/canals to intercept all the wastewater before discharging to the rivers/canals in the dry season. In the rainy season, a part of wastewater mixed with storm water will be intercepted and remaining diluted wastewater will be discharged directly to rivers/canals without any treatment. The collected wastewater by interceptor sewer will be transferred to the treatment plant through pumping stations and conveyance sewer.

For newly developed districts, Separate system is proposed which will collect only wastewater and storm water will be discharged by open ditches/channels. Collected wastewater will be conveyed to treatment plant.

The strategy of wastewater collection is summarized below.

Area	Sewerage System	Strategy
Inner City	Combined System	In dry season all the wastewater will be intercepted and in rainy season a part of wastewater mixed with storm water will be intercepted.
Newly Developed Area	Separate System	All wastewater will be collected in both seasons separately and treated before discharging. Storm water will be discharged without any treatment

7.3.2 Interceptor Capacity

Combined system is proposed to collect wastewater and stormwater from the inner city. If the interceptor is designed to intercept all the wastewater and stormwater during rainy season it will be very expensive. A supplementary study was carried out to find out optimum and acceptable capacity of interceptor so as to have cost effective size without polluting too much the water bodies. Refer to Supporting Report Appendix F, Section 6 for more details. Interceptor with the capacity of 3 times daily average wastewater gives 0.8 % higher annual BOD removal compared with that of one having capacity of 1.4 times daily average wastewater. But cost of interceptor having capacity 3 times the average daily wastewater is 10.7 % higher.

Hence interceptor is designed to carry 1.4 times the average daily wastewater flow.

7.4 Sanitation System

7.4.1 Technical Options for Sanitation Facilities

Individual On-Site sanitation facilities are faced with a variety of problems that make the construction and operation of such facilities a difficult undertaking. Some of the related problems are; stringent discharge requirements, high per capita cost, limited finances and limited operation and maintenance budgets. Thus effective low maintenance solutions must be developed to provide individual wastewater treatment facility. In this study, various alternatives for sanitation facilities are evaluated and main selection criteria are to identify the low cost alternative, which also requires least operation and maintenance. Following on-site sanitation systems are compared.

(a) Septic Tank
(b) Septic Tank with Soil Absorption Well
(c) Septic Tank with Sand Filter
(d) Septic Tank with Upflow Anaerobic Filter
(e) Johkasou

7.4.2 Proposed Sanitation Treatment System

Septic tank with upflow anaerobic filter, which requires low operation and maintenance, is proposed as on-site sanitation treatment system. The schematic diagram is shown in Fig. 7.5. Septic tank should be desludged once in a year utilizing vacuum trucks. Desludged septage is proposed to be treated at the sludge treatment facility of the wastewater treatment plant. Recommended cleaning of the filter media is once a year. Both desludging of septic tanks and cleaning of filter media can be done at the same time.

7.5 Wastewater Treatment System

7.5.1 Selection of Optimum Treatment System

As already discussed in previous sections, the wastewater treatment plants are to achieve the removal efficiency of at least a secondary treatment level. In view of this all possible secondary treatment processes have been evaluated with respect to efficiency and performance. Those not meeting the necessary requirements have been screened out from the study. Finally the following five treatment processes are evaluated:

(a) Stabilization Pond
(b) Aerated Lagoon
(c) Oxidation Ditch
(d) Conventional Activated Sludge
(e) Rotating Biological Contactor

These five (5) treatment processes are compared for the following criteria for selection of optimum treatment system.

(a) Adaptability to overload
(b) Required technology level of operation and maintenance
(c) Required construction cost and O/M cost
(d) Quantity of sludge to be disposed
(e) Required land acquisition

Table 7.4 shows the comparison of these processes. Stabilization pond and aerated lagoon system are appropriate if sufficient land is available. Area required for stabilization pond and aerated lagoon in each sewerage zone was calculated and details are mentioned below.

Zone	Treatment Capacity (m^3/day)	Area Required (ha)	
		Stabilization Pond	Aerated Lagoon
TLBC	131,000	128	38
NLTN	501,000	491	145
THLG	242,000	237	70
THBNDT	512,000	502	148
SW	111,000	109	32
SS	89,000	87	26
SN-I	139,000	136	40
SN-II	55,000	54	16
SE	167,000	164	48

The area requirement of stabilization pond as well as aerated lagoon is much more than the area available at the site, hence conventional activated sludge is proposed for the wastewater treatment. The flow diagram is shown in Fig. 7.6.

7.5.2 Design Capacity of Wastewater Treatment Plant

Wastewater treatment plants with combined sewage collection system, facilities except inlet pumps, grit chamber, disinfection basin and effluent facility will be designed for daily average wastewater discharge including groundwater infiltration. Inlet pumps, grit chamber, disinfection basin and effluent facility will be designed for the wet weather flow. Wet weather flow is determined as 1.4 times as daily average discharge in dry weather flow. Wastewater treatment plants with separate sewage collection system, facilities will be designed for daily average wastewater discharge with groundwater infiltration. Temperature is assumed to be 25 °C for designing treatment facilities.

7.6 Comprehensive Plan of Sewerage Development

As discussed in the previous sections, the study area is planned to have nine (9) sewerage zones. Based on the planning conditions, selected options for collection and treatment system and design criteria as discussed in the previous sections, comprehensive plan of sewerage development is prepared for each zone.

7.6.1 Tau Hu – Ben Nghe – Doi – Te Sewerage (THBNDT) Zone

(1) General

This zone is located at the central part of the inner city of Ho Chi Minh City and consists of total 88 wards from 9 districts. The canals of Tau Hu, Ben Nghe, Doi and Te flow from west to east and vice versa in this zone. The zone is enclosed by

the Saigon river to the east, Te canal and boundary of District 8 to the south, boundary of Tan Hoa – Lo Gom zone to the west and boundary of Nhieu Loc - Thi Nghe zone to the north. The zone covers an area of 3,065 ha with an existing population of 1,468,703. The average population density of all wards in this zone is 479 person/ha, which ranges from 114 person/ha of Ward Ben Nghe in District 1 to 1,417 person/ha of Ward 5 in District 8.

The existing land use pattern in this zone is summarized as follows.

(a) The area near by Saigon river in District 1 is mainly occupied by commercial and institutional facilities.
(b) Many illegal houses are located along four (4) canals of Tau Hu, Ben Nghe, Doi and Te.
(c) The area of District 4 enclosed by Saigon river, Ben Nhge and Te canals is a residential area with high population density.
(d) The western part of this zone in District 6 is occupied by residential and commercial area which were developed in old time.

Based on the future land use plan for the year 2020 prepared by Urban Planing Institute (UPI) in PCHCM, no drastic changes of land use are proposed. The legal and illegal houses along and on the canals are planed to be relocated in new developed districts. The existing and future land use of this zone are compared as shown below.

Land use	Existing	Future (2020)
Residential area including commercial and institutional areas	1,969 ha	2,204 ha
Industrial area	195 ha	32 ha
Green space	72 ha	122 ha
Agricultural area	163 ha	-
Others (roads and water ways)	666 ha	707 ha
Total	3,065 ha	3,065 ha

The projected future population of THBNDT zone will be reduced to 1,390,282, and the net population density, which is population per inhabitable area (residential, commercial and institutional and industrial areas), is estimated to be 622 person/ha. Sewerage system covers the residential, commercial, institutional and small industrial area of 2,236 ha.

(2) Collection System

The existing combined sewer system covers an area of 2,403 ha of the THBNDT sewerage development zone as shown in Fig. 7.7. Interceptor sewer along Tran

Hung Doa road and both sides of canals of Tau Hu, Ben Nghe, Doi and Te are proposed. Diameter of intereceptor sewer ranges from 500 mm to 2,500 mm. Conveyance sewer with a diameter of 2,500 mm is proposed from Ward 3 in District 8 to the proposed treatment plant site along Chanh Hung road. Total length of the conveyance sewer is about 6,400 m.

Pumping station with an ultimate capacity of 356 m^3/min for dry weather flow and 499 m^3/min for wet weather flow are proposed at the location of Ward 3 in District 8. Proposed collection sewer length is presented in Table 7.5. The collection system of THBNDT sewerage zone is summarized below:

Type of Collection System	Combined
Service Area (ha)	2,236
Service population in 2020	1,390,282
Population Density (per./ha)	622
Sewer	
Interceptor sewer (m)	34,750
Conveyance sewer (m)	6,400
Total	37,919

(3) Treatment Plant

Swamp area enclosing Cay Kho canal to the east and Go Noi canal to the west and south is proposed as the location of wastewater treatment plant for THBNDT sewerage zone. The area is located in Ward Phuoc Loc in Nha Be District.

Conventional activated sludge system with a capacity of 512,000 m^3/day for this zone requires an area of about 37 ha, which includes the sludge treatment system and other auxiliary as well.

The treated effluent is proposed to discharge to Cay Kho canal. Layout of treatment plant is shown in Fig. 7.8.

7.6.2 Nhieu Loc – Thi Nghe (NLTH) Sewerage Zone

(1) General

This zone is the largest zone among nine (9) sewerage development zones. This zone covers whole or part of 70 wards in seven (7) districts of District 1, 3, 10, Binh Thanh, Go Vap, Phu Nhuan and Tan Binh. The zone is bounded by Saigon river to the east, boundary of TLBC zone and Tan Son Nhat airport to the north, boundary of THLG zone to the west and boundary of THBNDT zone to the south. The NLTN zone covers an area of 3,935 ha with an existing population of

1,217,258. Average population density of all wards is 309 person/ha which ranges from 18 person/ha of Ward 15 in District Tan Binh to 873 person/ha of Ward 17 in District Phu Nhuan.

Existing land use pattern of this zone is summarized as follows.

(a) Residential area mainly occupies this zone.
(b) Military base is located at the northern fringe near the airport.
(c) Agricultural area is still remained in District Binh Thanh.

Based on the future land use plan, existing industrial area will be relocated to the newly developed industrial zones. Agricultural area will be replaced by the green space. The existing and future land use of this zone are compared as shown below.

Land use	Existing	Future (2020)
Residential area including Commercial and Institutional areas	3,045 ha	3,084 ha
Industrial area	146 ha	0 ha
Green Space	84 ha	200 ha
Agricultural area	124 ha	4 ha
Others (roads and water ways)	536 ha	647 ha
Total	3,935 ha	3,935 ha

The projected population in the year 2020 is 1,359,569 with a net population density of 441 person/ha. Proposed sewerage system covers the residential, commercial and institutional areas of 3,084 ha.

(2) Collection System

The existing combined sewer system covers an area of 2,132 ha or 69 % of the NLTN sewerage development zone covering the residential, commercial and institutional area as shown in Fig. 7.9. The combined sewage collection system is proposed in the remaining area of 952 ha. Interceptor sewer installed in the maintenance road along both sides of canals of Nhieu Loc and Thi Nghe are proposed. Conveyance sewer with a diameter of 2,500 mm is proposed from the estuary of Thi Nghe canal to the proposed treatment plant at Ward Phuoc Loc in District Nha Be along roads of Ton Duc Thang and Ben Chuong Duong.

Five (5) pumping stations are proposed as shown below.

Location	Capacity (m^3/min.)	
	Dry Weather Flow	Wet Weather Flow
Do Bridge of Lang canal	95	133
Cong Ly Bridge of Nhieu Loc canal	95	133
Tran Khac Chan Rd.	158	221
Huynh Man Dat Rd.	316	442
Y Bridge	316	442

Proposed collection system of NLTN zone is described in Table 7.5. The collection system of NLTN sewerage zone is summarized below:

Type of Collection System	Combined
Service Area (ha)	3,084
Service population in 2020	1,359,569
Population Density (per./ha)	441
Sewer	
Interceptor sewer (m)	32,033
Conveyance sewer (m)	9,358
Total	41,391

(3) Treatment Plant

Wastewater from NLTN is also proposed to be treated at the site of treatment plant of THBNDT. Proposed wastewater and sludge treatment processes are also same as those of THBNDT treatment plant. The proposed capacity of NLTN treatment plant is 501,000 m^3/day and its required land space is about 33 ha.

The treated effluent is proposed to discharge to Cay Kho canal. Proposed layout of treatment plant is shown in Fig. 7.8.

However, PCHCMC recently started that Cat Lai area in District 2 is also high potential site as the location of treatment plant of Nhieu Loc – Thi Nghe sewerage development zone. The further discussion will be done in the detailed design stage.

7.6.3 Tan Hoa – Lo Gom Sewerage Zone

(1) General

This Tan Hoa - Lo Gom sewerage zone covers the drainage area of Tan Hoa and Lo Gom canals consisting of 32 wards in five (5) districts of District 6, 8, 11, Tan Binh and Binh Chanh. This zone is bordered by boundaries of THBNDT and

NLTN sewerage zones to the east, Tan Ky Tan Quy Road to the north, Binh Long and An Duong Vuong Roads to the west and Tau Hu canal to the south. The zone covers an area of 2,447 ha with an existing population of 542,108. The average population density of all wards in this zone is 222 person/ha which ranges from 20 person/ha of Ward 10. Binh Tri Dong in District Binh Chanh to 1,299 person/ha of Ward 6 in District 6.

The existing land use pattern in this zone is summarized as follows.

(a) The residential area mainly occupies in this zone.
(b) Many small industrial areas are distributed.
(c) Dam Sen park of about 26 ha is located in this sewerage zone.

Based on the future land use plan for the year 2020, commercial center will be developed along An Duong Vuong Rd. The existing and future land use of this zone are compared below.

Land use	Existing	Future (2020)
Residential area including commercial and institutional areas	1,385 ha	1,887 ha
Industrial area	162 ha	59 ha
Green area	20 ha	192 ha
Agricultural area	686 ha	3 ha
Others	194 ha	306 ha
Total	2,447 ha	2,447 ha

The projected future population of this zone is 655,540 in the year 2020 with an average net population density of 337 person/ha. Sewerage system covers the residential, commercial, institutional and small industrial areas of 1,946 ha.

(2) Collection System

The existing combined sewer covers an area of 1,191 ha or 61 % of the THLG sewerage zone as shown in Fig. 7.10. The combined sewer system will be proposed to collect wastewater from the remaining area of 755 ha. Interceptor sewer is proposed along both sides of Tan Hoa and Lo Gom canals with a total length of 16 km. Conveyance sewer with a diameter of 2,500 mm is installed along Ben Luc river to the treatment plant site.

Pumping stations are proposed at three (3) locations of Ward 20 in District Tan Binh, Ward 14 and Ward 10 in District 6 along Tan Hoa Lo Gom canals. The ultimate capacity of each pumping station is as follows.

Location	Capacity (m^3/min.)	
	Dry Weather Flow	Wet Weather Flow
Hoa Binh Rd. near Tre Bridge	46	65
Hung Vuong Rd. near Ong Buong Bridge	76	107
Nyuyen Van Luong Rd.	122	171

Proposed collection sewer length is presented in Table 7.5. The collection system of THLG zone is summarized below:

Type of Collection System	Combined
Service Area (ha)	1,946
Service population in 2020	655,540
Population Density (per./ha)	337
Sewer	
Interceptor sewer (m)	16,305
Conveyance sewer (m)	6,564
Total	22,869

(3) Treatment Plant

Agricultural area near-by Ba Goc canal in Ward Tan Kien in District Binh Chanh is proposed as the location of treatment plant for THLG sewerage zone. Conventional activated sludge system with a capacity of 242,000 m^3/day is proposed with an area of 20 ha, which includes sludge treatment system and other auxiliary as well.

The treated effluent is proposed to be discharged to Ba Goc river. Proposed layout of treatment plant is shown in Fig. 7.11.

7.6.4 Tham Luong – Ben Cat (TLBC) Sewerage Zone

(1) General

TLBC zone covers mainly District Go Vap and partially District Binh Thanh consisting of 11 wards. This zone is enclosed by Saigon river to the east, boundary of District 12 to the north, boundary of Ward 12 in District Go Vap to the west and Tan Son Nhat airport and railway to the south. The zone covers an area of 1,495 ha with an existing population of 185,696. Existing population density of all wards covered by this zone is 124 person/ha, which ranges from 61 person/ha in Wards 13 of District Binh Thanh to 367 person/ha in Wards 4 of District Go Vap.

Based on the future land use plan, existing military space will be transferred to the residential area. Existing small industrial area will be relocated to the newly

developed districts. Agriculture area will be also transferred to residential and green space in future. The existing and future land use of this zone is compared as shown below.

Land use	Existing	Future (2020)
Residential area including commercial and institutional areas	790 ha	1,116 ha
Industrial area	27 ha	0 ha
Green area	21 ha	114 ha
Agricultural area	522 ha	4 ha
Others	135 ha	261 ha
Total	1,495 ha	1,495 ha

Green area of 114 ha, agricultural area of 4 ha and other areas of 260 ha will not be covered by the sewerage system. Hence, sewerage system will cover an area of 1,116 ha consisting of residential, commercial and institutional areas. The projected future population in the year 2020 is 354,857 with an average net population density of 318 person/ha.

(2) Collection System

The existing combined system covers an area of 421 ha or 38 % of the TLBC sewerage development zone as shown in Fig. 7.12. The combined sewer system is adopted for this sewerage zone. Interceptor sewer is proposed along the right bank of Ben Cat river. The diameter of proposed interceptor sewer ranges from 700 mm to 1,600 mm. Conveyance sewer of 1,600 mm diameter with a total length of 635 m will be installed to the proposed treatment plant site.

Pumping station with a capacity of 42 m^3/min. for dry weather flow and 59 m^3/min. for wet weather flow is proposed on the right bank of Ben Cat river in Ward 17 of District Go Vap.

Proposed collection sewer length is presented in Table 7.5. The collection system of TLBC sewerage zone is summarized below.

Type of Collection system	Combined
Service Area (ha)	1,116
Service population in 2020	354,857
Population Density (per./ha)	318
Sewer	
Interceptor sewer (m)	9,356
Conveyance sewer (m)	635
Total	9,991

(3) Treatment Plant

The green space enclosing Saigon river to the west, Vam Thuat river to the west and south is proposed as the location of treatment plant for TLBC sewerage zone. The area is located in Ward 17 of District 12. Conventional activated sludge system with a capacity of 131,000 m^3/day requires an area of about 11 ha, which includes the space for sludge treatment facilities and other auxiliary as well.

The treated effluent is proposed to be discharged to Saigon river. Proposed layout of treatment plant is shown in Fig. 7.13.