TABLES AND FIGURES

TABLE 9.1 (1) PROPOSED FACILITIES FOR STORMWATER DRAINAGE IMPROVEMENT PLAN (1)

Area	Proposed Facilities		Total
A-1			
IV-3 ii	Construction of Drainage Channel		L= 2,300 m
	Box Culvert (3m x 2.6m)		(800 m)
	Concrete Lining Open Channel (1.5m x 1.5m, 0.5)		(1,300 m)
OS	Construction of Drainage Channel		L= 800 m
	Box Culvert (1.5m x 1.8m)		(800 m)
F.T.	Construction of Grand-Yoff Infiltration Pond 1		A= 5 ha
A-2			
O.B.	Construction of Ouakam Infiltration Ponds (2 pls)		A= 3.24 ha
	Construction of Drainage Channel		L= 2,050 m
	Concrete Lining Open Channel (1.5m x 1.5m, 0.5)		(2,050 m)
G.Y.			
G.Y. 1	Drain to Grand Niaye		
	Construction of Drainage Channel		L= 3,850 m
	Concrete Lining Open Channel (3.0m x 1.7m, 0.5)		(2,800 m)
	Concrete Lining Open Channel (1.5m x 1.5m, 0)		(1,050 m)
	Construction of Patte d'Oie Infiltration Pond (2 pls)		A= 4 ha
G.Y. 2	Drain to Grand-Yoff Infiltration Pond		
	Construction of Drainage Channel		L= 1,200 m
	Box Culvert (2m x 2m x 2)		(500 m)
	Concrete Lining Open Channel (2m x 2m, 0.5)		(700 m)
	Stormwater Pumping Station (Q=1.5 m3/s)		1 place
	Stormwater Transmission Pipe (DCIP d=1,100mm)		L= 300 m
	Construction of Grand-Yoff Infiltration Pond 2		A= 2.25 ha
A-3			
Al S	Construction of Drainage Channel		L= 6,150 m
	Earth Channel (9m x 2m, 2)		(2,850 m)
	Concrete Lining Open Channel (2.5m x 1.6m, 0.5)		(3,300 m)
Al N1	Construction of Airport Infiltration Pond		A= 1 ha
Al N2	Improvement of Existing Channel		L= 1,300 m
	Concrete Lining Open Channel (2m x 1.2m, 0)		(1,300 m)
C.Y.	Improvement and Construction of Drainage Channel		L= 3,500 m
	Concrete Lining Open Channel (2m x 1.6m, 0.5)	Construction	(2,850 m)
	Concrete Lining Open Channel (2m x 1.6m, 0.5)	Improvement	(650 m)

TABLE 9.1 (2) PROPOSED FACILITIES FOR STORMWATER DRAINAGE IMPROVEMENT PLAN (2)

Area	Proposed Facilities			Total
A-6				
CP EP	Construction of Main Drainage Channel along National Road Concrete Lining Open Channel (3m x 1.5m,1)			L= 3,610 m
CP				
CP 1	Drain to Grand Nlaye			
	Construction of Storm Sewer		2 Systems Total	L= 4,460 m
	C.P.1-1			(L=2,970m)
		d=1,100mm CP		(250m)
		d=1,000mm CP		(1,050m)
		d=900mm CP		(620m)
		d=800mm CP		(1,050m)
	C.P.1-2			(L=1,490m)
		d=1,100mm CP		(260m)
		d=1,000mm CP		(550m)
		d=600mm CP		(680m)
	Construction of open channel (2m x 0.4 - 0.6m, 1)		2 Systems Total	L = 400m
	C.P.1-1			(100 m)
	C.P.1-2			(300 m)
	Stormwater Pumping Station		2 Systems Total	7 pls
	C.P.1-1 (1.0 m3/s 2pls, 0.3 m3/s 1pls)			3 pls
	C.P.1-2 (1.5 m3/s , 1.0 m3/s, 0.5m3/s, 0.3m3/s)			4 pls
	Stormwater Transmission Pipe (Ductile Iron Pipe)		2 Systems Total	L= 2,630m
	C.P. 1-1			(L=690m)
		d=600mm DCIP		(420m)
		d=800mm DCIP		(270m)
	C.P. 1-2			(L=1,940m)
		d=600mmDCIP		(570m)
		d=1100mm DCIP		(920m)
		d=801mm DCIP		(450m)
CP 2	Drain to Sea			
	Construction of main Drainage Channel (1-3m x 0.4-1.6m, 1)			L = 2,940 m
	Improvement of Existing Drainage Channel (3m x 0.9m, 1)			L= 770 m
	Stormwater Pumping Station (1.5 m3/s)			1 Place
	Retention Pond		Total	5 .1ha
A-7				
L1	Construction of Drainage Channel Concrete Lining Open Channel (4.5m x 1.5m, 0.5)			L= 1,750 m

TABLE 9.2 UNIT PRICE/COST FOR WORK ITEMS

Item	Unit	Unit Price/Cost
Open Channel		
Earth Channel		
Type I (B=9m, H=2m, m=2)	m	207,700
Concrete Lining Open Channel		
Type I (B=4.5m, H=1.5m, m=0.5)	m	295,300
Type III (B=3m, H=1.7m, m=0.5)	m	271,280
Type IV (B=3m, H=1.7m, m=1)	m	311,000
Type V (B=2.5m, H=1.6m, m=0.5)	m	226,710
Type V (B=2m, H=2m, m=0)	m	310,650
Type VI (B=2m, H=1.6m, m=1)	m	196,000
Type VII (B=2m, H=1.6m, m=0.5)	m	190,000
Type VIII (B=2m, H=1.2m, m=0)	m	164,600
Type IX (B=1.5m, H=1.5m, m=0.5)	m	188,900
Type X (B=1.5m, H=1.5m, m=0)	m	176,150
Type XI (B=1m, H=1.m, m=1)	m	162,000
Box Culvert		
Type I (B=3m, H=2.6m)	m	640,800
Type II (B=1.8m, H=1.5m)	m	387,960
Type III (B=3m, H=2.5m x 2)	m	1,226,480
Storm Sewer		
Type I (d=600mm Concrete Pipe)	m	316,000
Type II (d=800mm Concrete Pipe)	m	378,000
Type III (d=900mm Concrete Pipe)	m	413,000
Type IV (d=1,000mm Concrete Pipe)	m	466,000
Type V (d=1,100mm Concrete Pipe)	m	525,000
Infilteration Pond	ha	31,680,000
Retention Pond	ha	42,500,000
Storm Water Pumping Station		
Type I (0.3 m2/s)	pls	209,800,000
Type II (0.5 m3/s)	pls	242,800,000
Type III (1.0 m3/s)	pls	311,800,000
Type IV (1.5m3/s)	pls	395,900,000
Transmission Pipe Line		
Type I (d=600mm Ductile Iron Pipe)	m	283,700
Type II (d=800mm Ductile Iron Pipe)	m	387,300
Type III (d=1,100mm Ductile Iron Pipe)	m	608,600
Land Acquisition	m2	1,650

TABLE 9.3 WORK VOLUME FOR THE MASTER PLAN

Item	Unit	A-1			A-2			A-3				A-6			A-7
						G.Y.							CP		
		IV-3 ii	OS	F.T.	O.B.	G.Y.1	G.Y.2	Ai S	Ai N1	Ai N2	C.Y.	EP	CP1	CP2	L1
Open Channel															
Earth Channel															
Type I (B=9m, H=2m, m=2)	m							2,850							
Concrete Lining Open Channel															
Type I (B=4.5m, H=1.5m, m=0.5)	m														1,750
Type III (B=3m, H=1.7m, m=0.5)	m					2,800									
Type IV (B=3m, H=1.5m, m=1)	m											2,850		2,710	
Type V (B=2.5m, H=1.6m, m=0.5)	m							3,300							
Type V (B=2m, H=2m, m=0)	m						700								
Type VI (B=2m, H=1.6m, m=1)	m												400	300	
Type VII (B=2m, H=1.6m, m=0.5)	m										3,500				
Type VIII (B=2m, H=1.2m, m=0)	m									1,300					
Type IX (B=1.5m, H=1.5m, m=0.5)	m	1,300			2,050										
Type X (B=1.5m, H=1.5m, m=0)	m					1,050									
Type XI (B=1m, H=1.m, m=1)	m													700	
Box Culvert															
Type I (B=3m, H=2.6m)	m	800													
Type II (B=1.8m, H=1.5m)	m		800												
Type III (B=3m, H=2.5m x 2)	m						500								
Storm Sewer															
Type I (d=600mm Concrete Pipe)	m												680		
Type II (d=800mm Concrete Pipe)	m												1,050		
Type III (d=900mm Concrete Pipe)	m												620		
Type IV (d=1,000mm Concrete Pipe)	m												1,600		
Type V (d=1,100mm Concrete Pipe)	m												510		
Infilteration Pond	ha			5.00	3.24	4.00	2.25		1.00						
Retention Pond	ha												2.50	5.10	
Storm Water Pumping Station															
Type I (0.3 m2/s)	pls												2		
Type II (0.5 m3/s)	pls												1		
Type III (1.0 m3/s)	pls												3		
Type IV (1.5m3/s)	pls						1						1	1	
Transmission Pipe Line															
Type I (d=600mm Ductile Iron Pipe)	m												1,190		
Type II (d=800mm Ductile Iron Pipe)	m												990		
Type III (d=1,100mm Ductile Iron Pipe)	m						300						450		
Land Acquisition	m2			60,000	39,000	48,000	32,000		12,000				25,000	51,000	

TABLE 9.4 PROJECT COST FOR THE MASTER PLAN

Unit : x 1000 FCFA

Item	Unit	Unit Price/Cost (FCFA)	A-1			A-2			A-3				A-5			A-7	Dakar and Pikine	Total
							G.Y.							CP				
			IV-3 ii	OS	F.T.	O.B.	G.Y.1	G.Y.2	Al S	Al N1	Al N2	C.Y.	EP	CP1	CP2	L1		
I. Direct Construction Cost																		
1 Open Channel																		
Earth Channel																		
Type I (B=9m, H=2m, m=2)	m	207,700							591,945									591,945
Concrete Lining Open Channel																		
Type I (B=4.5m, H=1.5m, m=0.5)	m	295,300														516,775		516,775
Type II (B=3m, H=1.7m, m=0.5)	m	271,280					759,584											759,584
Type III (B=3m, H=1.7m, m=1)	m	311,000											886,350		842,810			1,729,160
Type IV (B=2.5m, H=1.6m, m=0.5)	m	226,710							748,143									748,143
Type V (B=2m, H=2m, m=0)	m	310,650						217,455										217,455
Type VI (B=2m, H=1.6m, m=1)	m	196,000												78,400	58,800			137,200
Type VII (B=2m, H=1.6m, m=0.5)	m	190,000										665,000						665,000
Type VIII (B=2m, H=1.2m, m=0)	m	164,600									213,980							213,980
Type IX (B=1.5m, H=1.5m, m=0.5)	m	188,900	245,570			387,245												632,815
Type X (B=1.5m, H=1.5m, m=0)	m	176,150					184,958											184,958
Type XI (B=1m, H=1.m, m=1)	m	162,000													113,400			113,400
2 Box Culvert																		
Type I (B=3m, H=2.6m)	m	640,800	512,640															512,640
Type II (B=1.8m, H=1.5m)	m	387,960		310,368														310,368
Type III (B=3m, H=2.5m x 2)	m	1,226,480						613,240										613,240
3 Storm Sewer																		
Type I (d=600mm Concrete Pipe)	m	316,000												214,880				214,880
Type II (d=800mm Concrete Pipe)	m	378,000												396,900				396,900
Type III (d=900mm Concrete Pipe)	m	413,000												256,060				256,060
Type IV (d=1,000mm Concrete Pipe)	m	466,000												745,600				745,600
Type V (d=1,100mm Concrete Pipe)	m	525,000												267,750				267,750
4 Infilteration Pond	ha	31,680,000			158,400	102,643	126,720	71,280		31,680								490,723
5 Retention Pond	ha	42,500,000												106,250	216,750			323,000
6 Storm Water Pumping Station																		
Type I (0.3 m2/s)	pls	209,800,000												419,600				419,600
Type II (0.5 m3/s)	pls	242,800,000												242,800				242,800
Type III (1.0 m3/s)	pls	311,800,000												935,400				935,400
Type IV (1.5m3/s)	pls	395,900,000						395,900						395,900	395,900			1,187,700
7 Transmission Pipe Line																		
Type I (d=600mm Ductile Iron Pipe)	m	283,700												337,603				337,603
Type II (d=800mm Ductile Iron Pipe)	m	387,300												383,427				383,427
Type III (d=1,100mm Ductile Iron Pipe)	m	608,600						182,580						273,870				456,450
8 Secondary Drain			227,463	93,110	47,520	146,966	321,378	444,137	402,026	9,504	64,194	199,500	265,905	1,516,332	488,298	155,033		4,381,367
Sub-Total of (I)			985,673	403,478	205,920	636,855	1,392,640	1,924,592	1,742,114	41,184	278,174	864,500	1,152,255	6,570,772	2,115,958	671,808		18,985,922
II. Pumping Car																	500,000	500,000
III. Land Acquisition/Compensation																		
1 Land Acquisition	m2	1,650			99,000	64,350	79,200	52,800		19,800				41,250	84,150			440,550
2 Compensation	m3	1,650			99,000	64,350	79,200	52,800		19,800				41,250	84,150			440,550
Sub-Total of (II)					198,000	128,700	158,400	105,600		39,600				82,500	168,300			881,100
IV. Engineering Service		(7% of I)	68,997	28,243	14,414	44,580	97,485	134,721	121,948	2,883	19,472	60,515	80,658	459,954	148,117	47,027		1,329,015
V. Government Administration		(1.5% of I+III)	14,785	6,052	6,059	11,483	23,266	30,453	26,132	1,212	4,173	12,968	17,284	99,799	34,264	10,077		298,005
VI. Physical Contingency		(10% of I+III+IV+V)	106,946	43,777	42,439	82,162	167,179	219,537	189,019	8,488	30,182	93,798	125,020	721,303	246,664	72,891		2,149,404
VII. Project Cost			1,176,401	481,551	466,833	903,780	1,838,969	2,414,902	2,079,214	93,367	332,001	1,031,781	1,375,216	7,934,328	2,713,303	801,802	500,000	24,143,447

M/PCOST-2

TABLE 9.5 BREAKDOWN OF PROJECT COST

	CONSTRUCTION COST		
	FC	LC	TT
1st Priority			
a. Grand-Yoff			
1) Survey, Design, Contract Process	172,634	73,986	246,620
2) Land acquisition / Compensation	0	462,000	462,000
3) Pumping station / Pond	452,118	126,362	578,480
4) G.Y.1 drainage channels	141,681	802,861	944,542
5) G.Y.2 drainage channels	400,568	430,127	830,695
6) Infiltration pond	53,460	302,940	356,400
7) Government Administration	0	47,582	47,582
8) Physical contingency	0	346,632	346,632
Sub-total	1,220,461	2,592,590	3,812,951
b. Central Pikine			
1) Survey, Design, Contract Process	425,650	182,422	608,072
2) Land acquisition / Compensation	0	250,800	250,800
3) Pumping station / Pond	2,637,865	746,635	3,384,500
4) C.P.1 drainage channels	1,610,772	348,819	1,959,591
5) C.P.2 drainage channels	152,252	862,758	1,015,010
6) Retention pond	48,450	274,551	323,001
7) Secondary Drain	1,002,314	1,002,315	2,004,629
8) Government Administration	0	134,063	134,063
9) Physical contingency	0	967,967	967,967
Sub-total	5,877,302	4,770,420	10,647,631
2nd Priority			
Survey, Design, Contract Process	133,931	57,399	191,330
Land acquisition / Compensation	0	39,600	39,600
a. Dakar-Yoff airport			
1) Ouakam town drainge	112,221	635,922	748,143
2) Airport South channel	88,792	503,153	591,945
3) Airport North channel	32,097	181,883	213,980
4) Infiltration pond	4,752	26,928	31,680
b. Lac 1 Drainage Channels			
1) Construction cost	77,516	439,259	516,775
Government Administration	0	32,132	32,132
Physical contingency	0	236,558	236,558
Sub-total	449,309	2,512,851	2,602,142
3rd Priority			
Survey, Design, Contract Process	198,095	84,898	282,993
Land acquisition / Compensation	0	128,700	128,700
a. Channel IV-3			
1) Channel IV-3.2	344,420	413,790	758,210
2) O.S. drainage channel	186,221	124,147	310,368
b. Ouakam Basin			
1) Drainage channels	58,087	329,158	387,245
2) Infilteration pond	15,396	87,247	102,643
c. Yoff Channel			
1) Construction cost	99,750	565,250	665,000
d. Channel Along the Road (E.P.)			
1) Construction cost	132,952	753,398	886,350
Government Administration	0	48,578	48,578
Physical contingency		357,009	357,009
Sub-total	1,034,921	2,892,285	3,927,095
Secondary Drain & On-site Infiltration pond			
Construction cost	1,188,369	1,188,369	2,376,737
Government Administration	0	35,651	35,651
Physical contingency	0	241,239	241,239
Sub-total	1,188,369	1,465,300	2,653,627
Pumping Car	500,000	0	500,000
Total	10,270,362	14,233,446	24,143,446

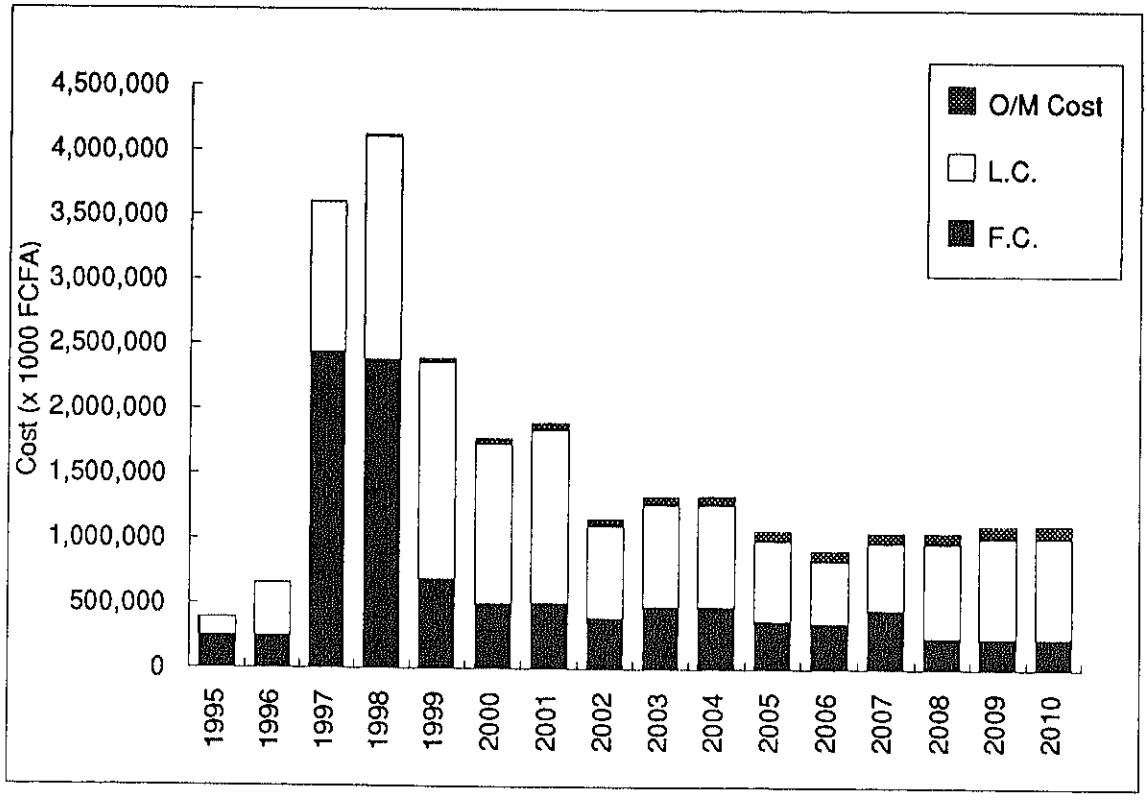
Unit : x 1000 FCFA

FC = Forign Currency Portion
LC = Local Currency Portion
TT = Total Currency Portion

TABLE 9.6 COST DISBURSEMENT SCHEDULE FOR DRAINAGE IMPROVEMENT PROJECT

	Construction Cost			O/M	
	F.C.	L.C.	Sub-Total	O/M Cost	Total
1995	251,188	143,536	394,724	0	394,724
1996	251,188	408,817	660,005	0	660,005
1997	2,435,873	1,160,882	3,596,755	1,446	3,598,201
1998	2,377,531	1,725,655	4,103,186	14,976	4,118,162
1999	689,886	1,668,460	2,358,346	34,604	2,392,950
2000	502,397	1,231,912	1,734,308	45,606	1,779,914
2001	506,006	1,338,250	1,844,255	53,298	1,897,554
2002	393,357	710,716	1,104,074	57,862	1,161,935
2003	479,462	788,349	1,267,811	63,372	1,331,183
2004	479,462	788,349	1,267,811	68,883	1,336,694
2005	372,110	621,330	993,440	75,169	1,068,609
2006	351,021	485,447	836,468	78,748	915,217
2007	458,547	516,503	975,050	81,828	1,056,878
2008	241,568	729,268	970,836	86,009	1,056,846
2009	240,383	777,806	1,018,189	90,469	1,108,658
2010	240,383	777,806	1,018,189	94,930	1,113,118
Total Cost (1995-2010)	10,270,362	13,873,084	24,143,446		

Unit : x 1000 FCFA



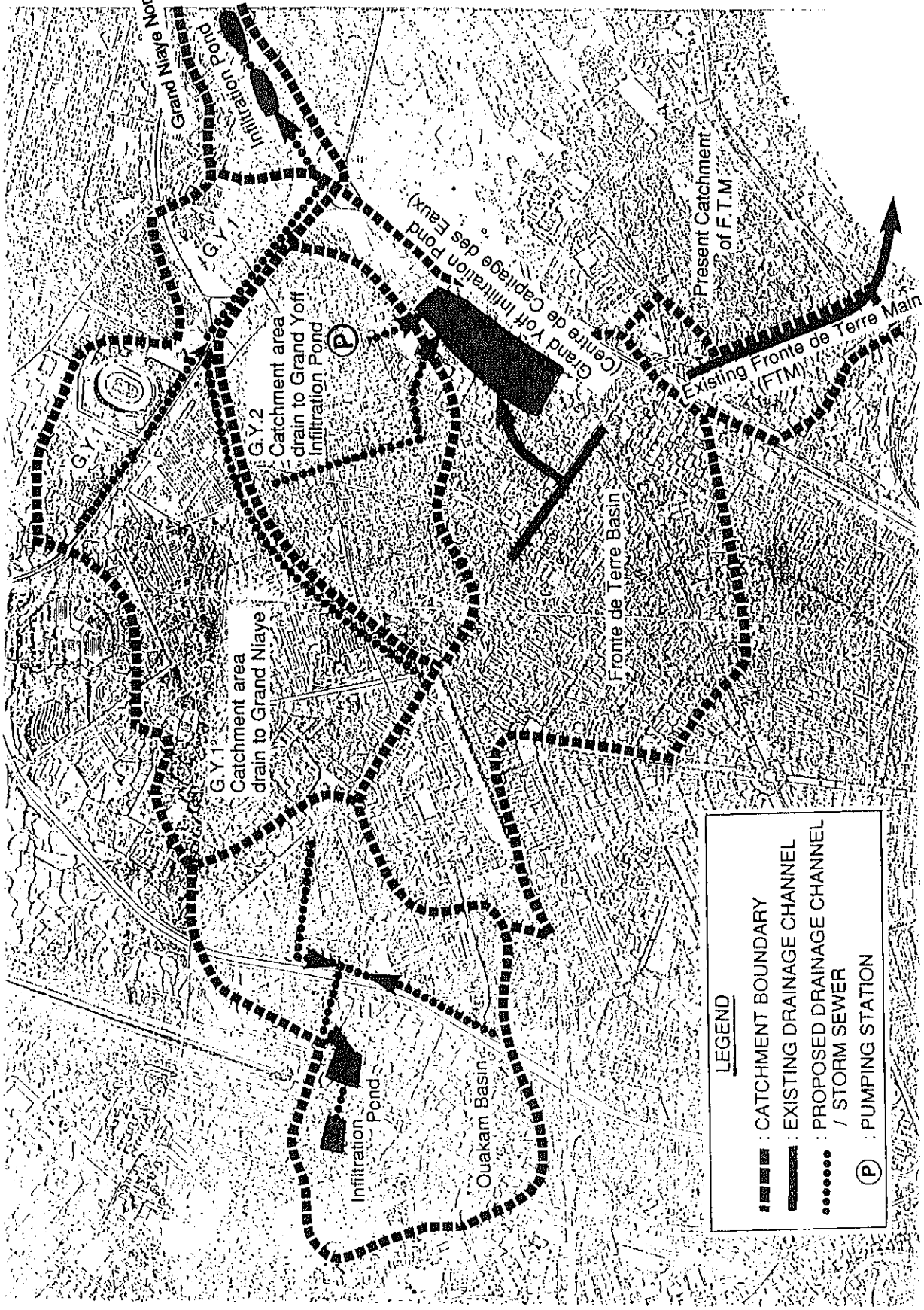


FIGURE 9.1 PROPOSED DRAINAGE IMPROVEMENT PLAN (FRONTE DE TERRE, GRAND YOFF, OUAKAM)

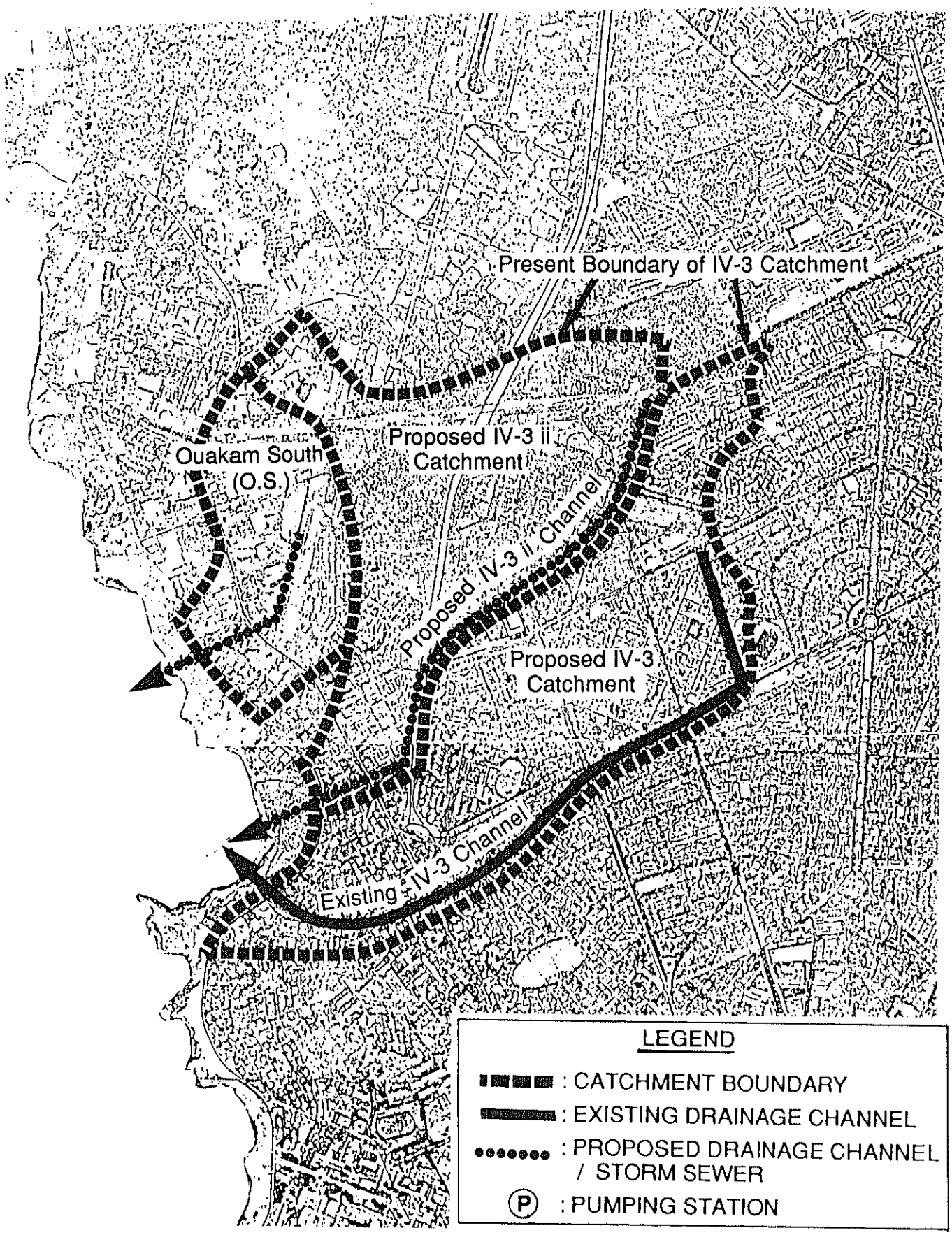


FIGURE 9.2 PROPOSED DRAINAGE IMPROVEMENT PLAN (IV-3 ii CHANNEL, OUAKAM SOUTH)

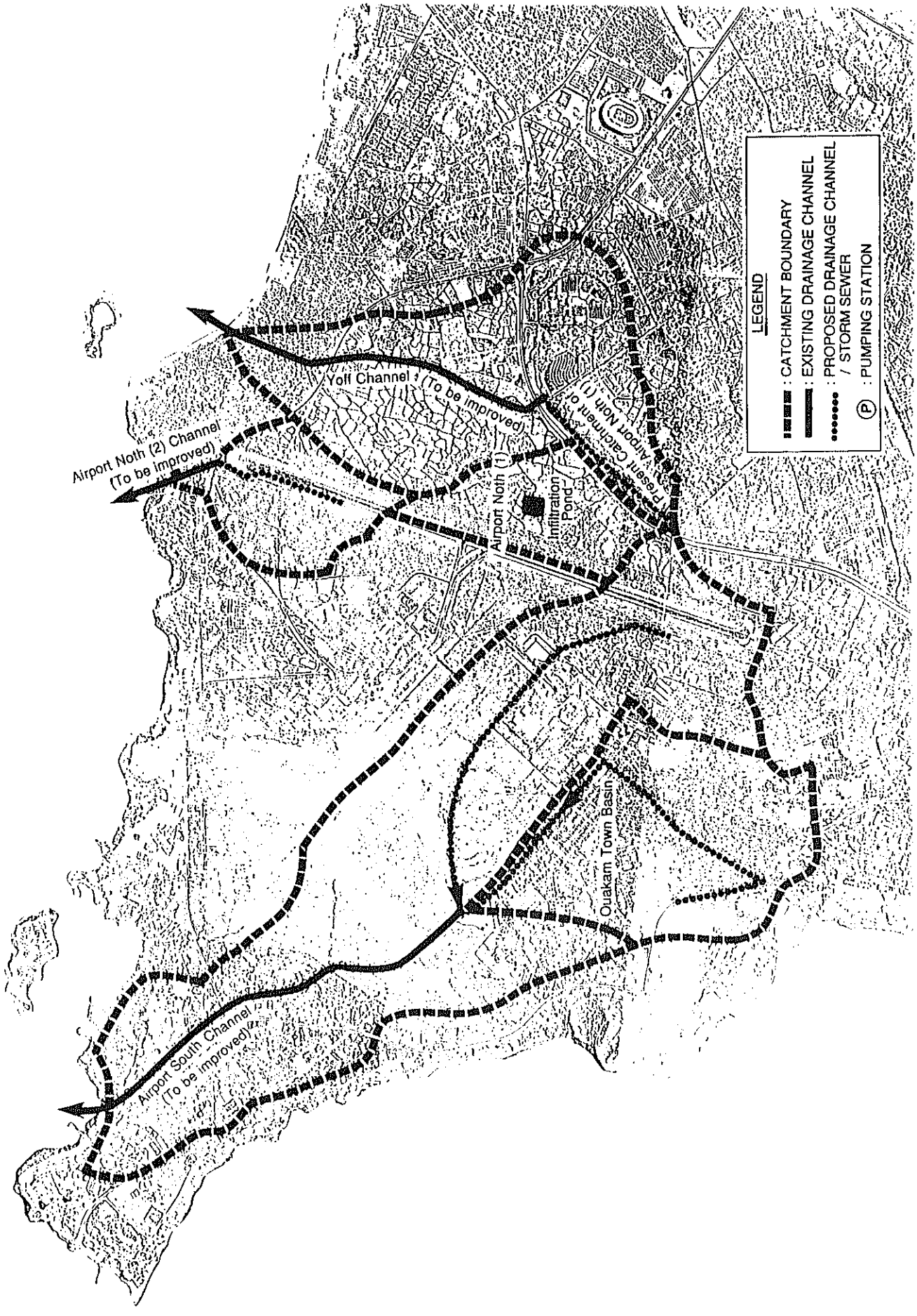


FIGURE 9.3 PROPOSED DRAINAGE IMPROVEMENT PLAN (DAKAR-YOFF AIRPORT)

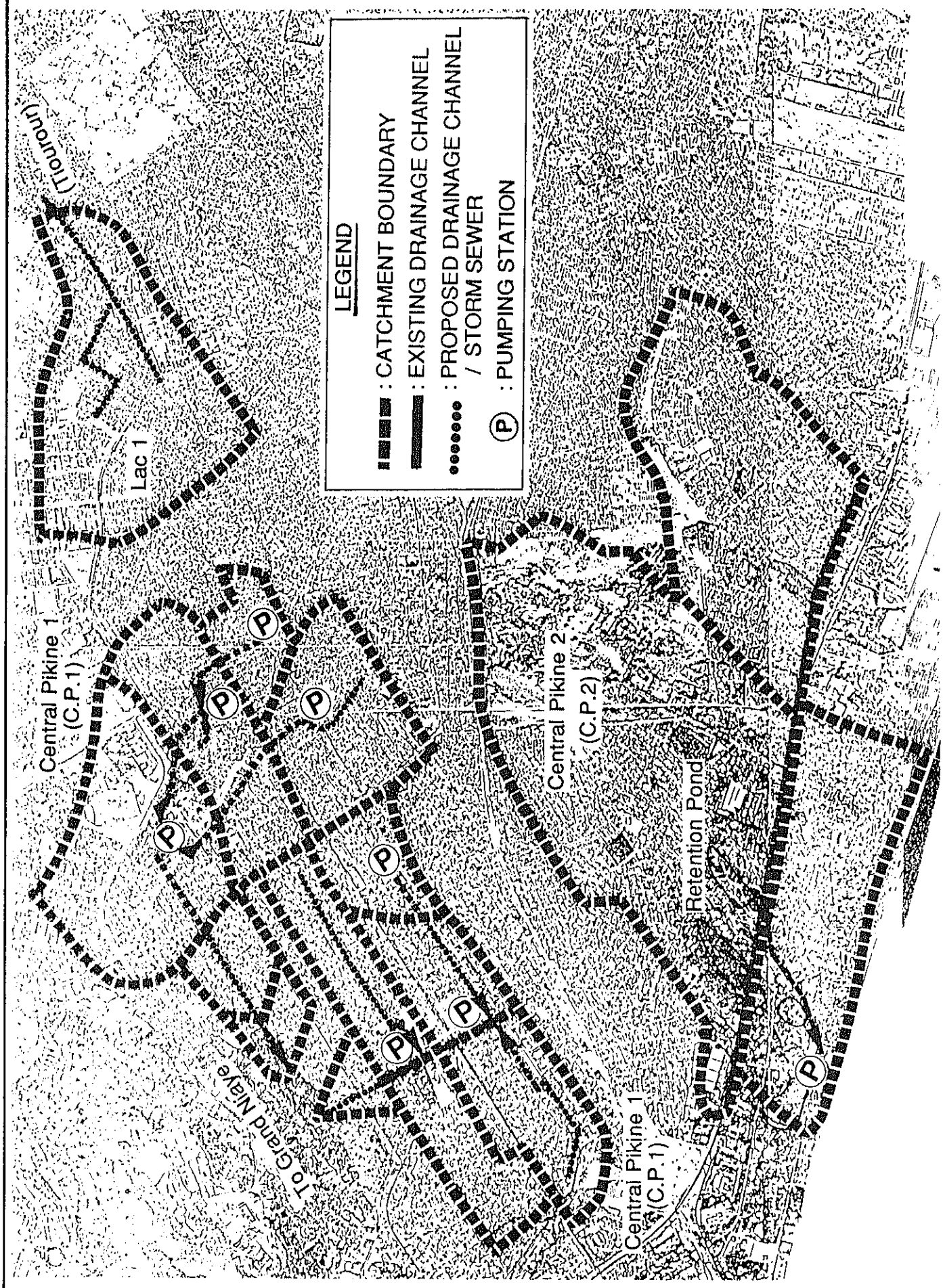


FIGURE 9.4 PROPOSED DRAINAGE IMPROVEMENT PLAN (PIKINE)

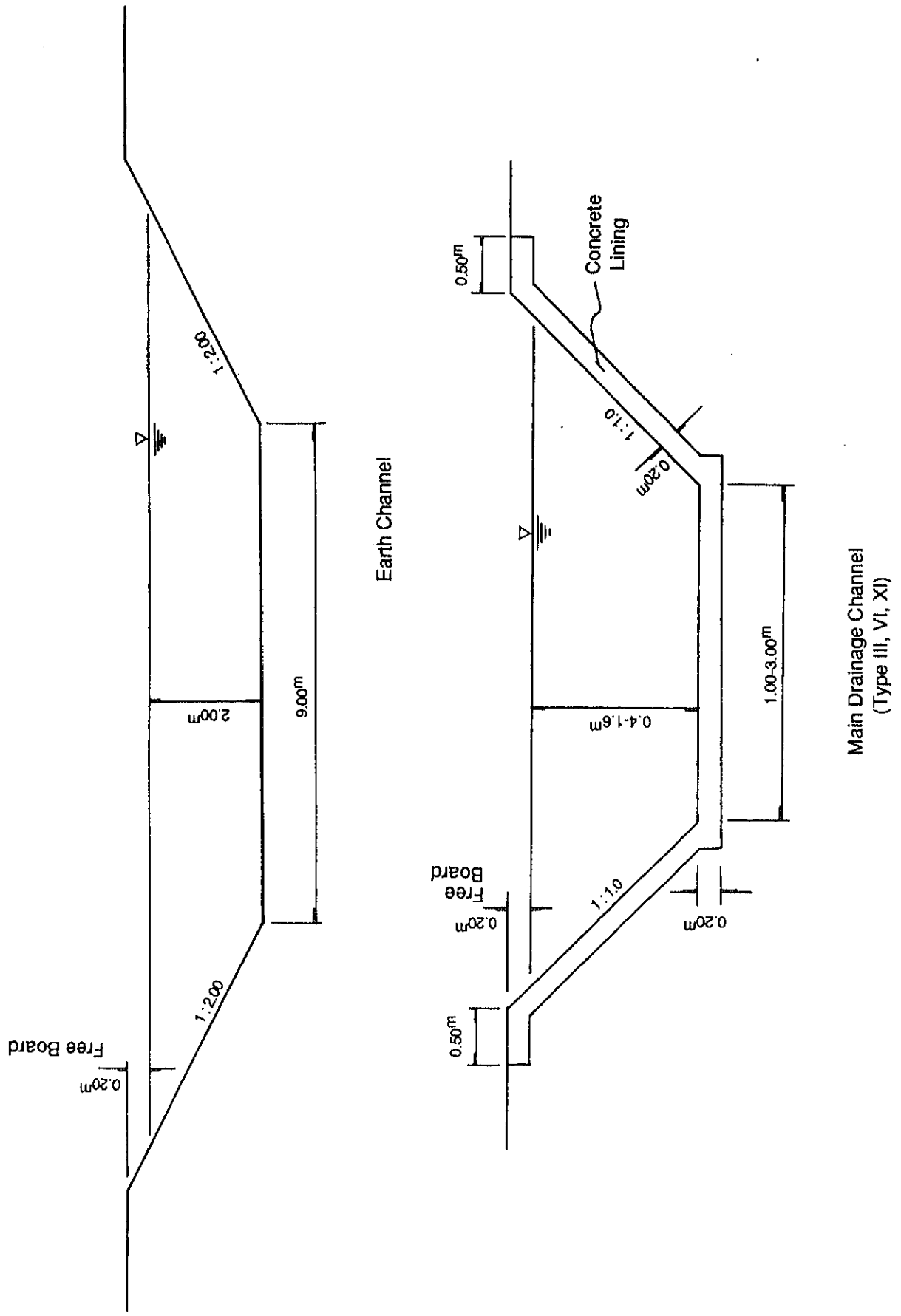
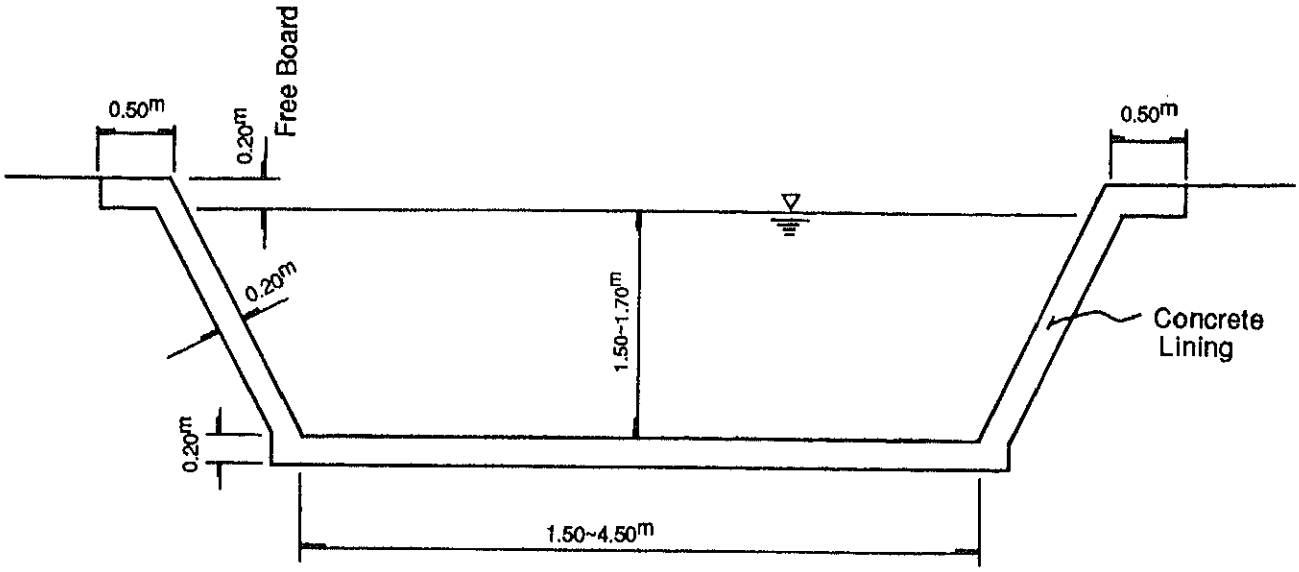
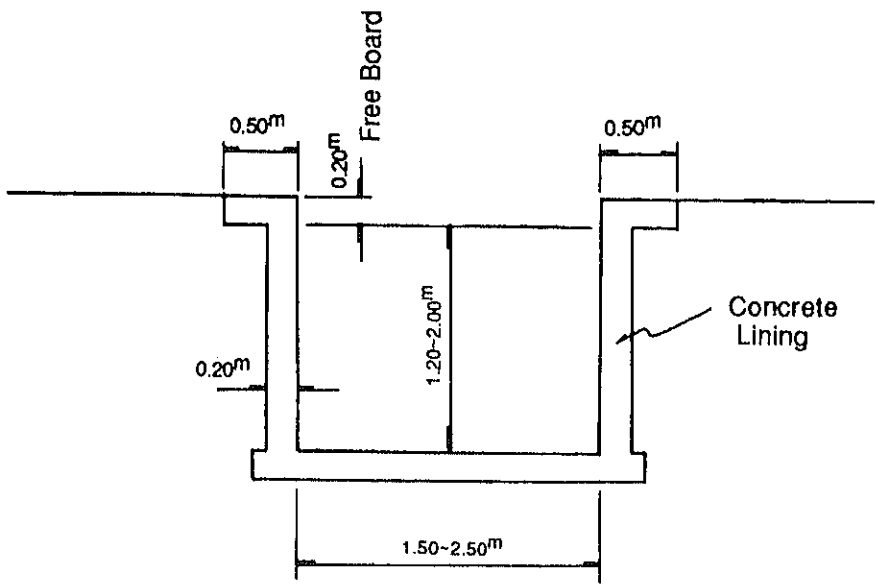


FIGURE 9.5 PROPOSED CROSS SECTION OF DRAINAGE CHANNEL (1)
(EARTH CHANNEL, MAIN DRAINAGE DITCH)



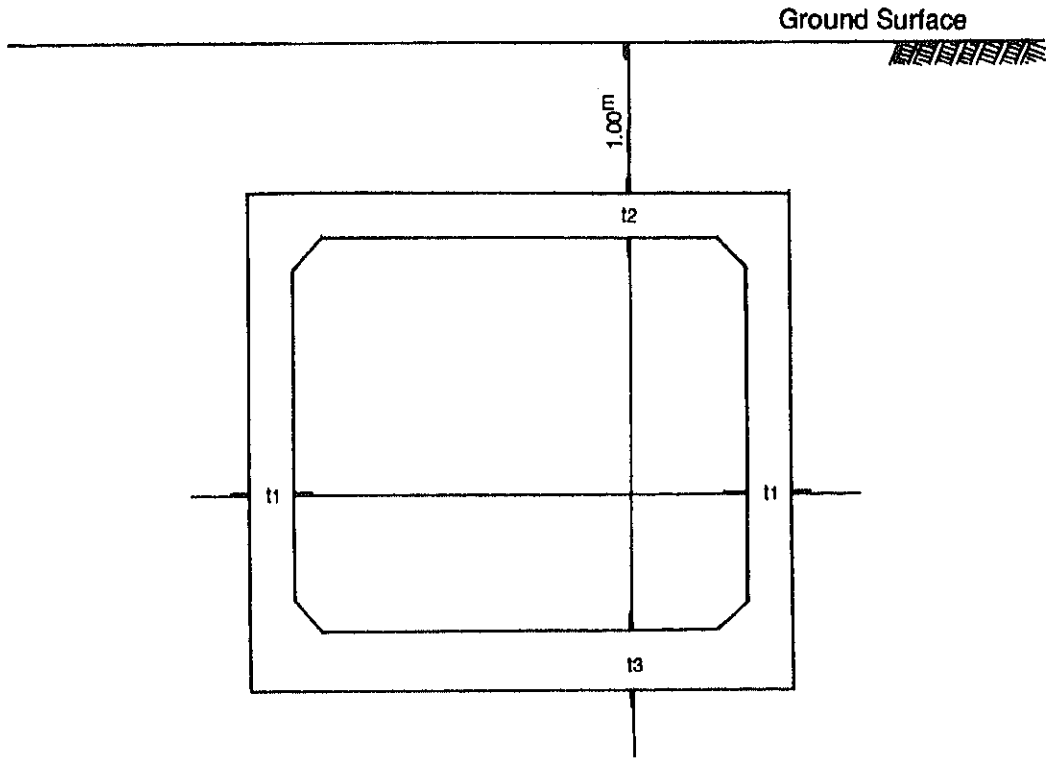
Concrete Lining Open Channel

Type I, II, IV, VII, IX



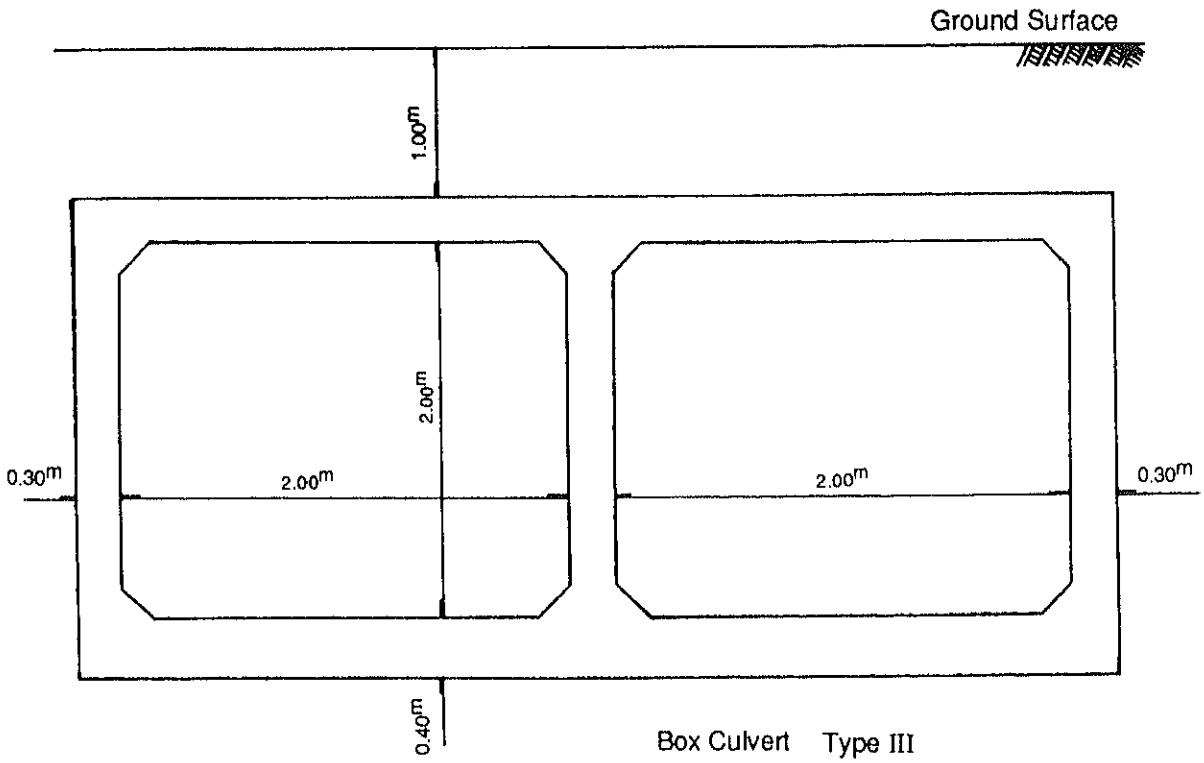
Concrete Lining Open Channel
Type V, VIII

FIGURE 9.6 PROPOSED CROSS SECTION OF DRAINAGE CHANNEL (2) (CONCRETE LINING OPEN CHANNEL)



Box Culvert
Type I and II

B = 3.00m, 1.08m
H = 2.00m, 1.05m
t1 = 0.30m, 0.25m
t2 = 0.30m, 0.25m
t3 = 0.40m, 0.30m



Box Culvert Type III

FIGURE 9.7 PROPOSED CROSS SECTION OF DRAINAGE CHANNEL (3) (BOX CULVERT)

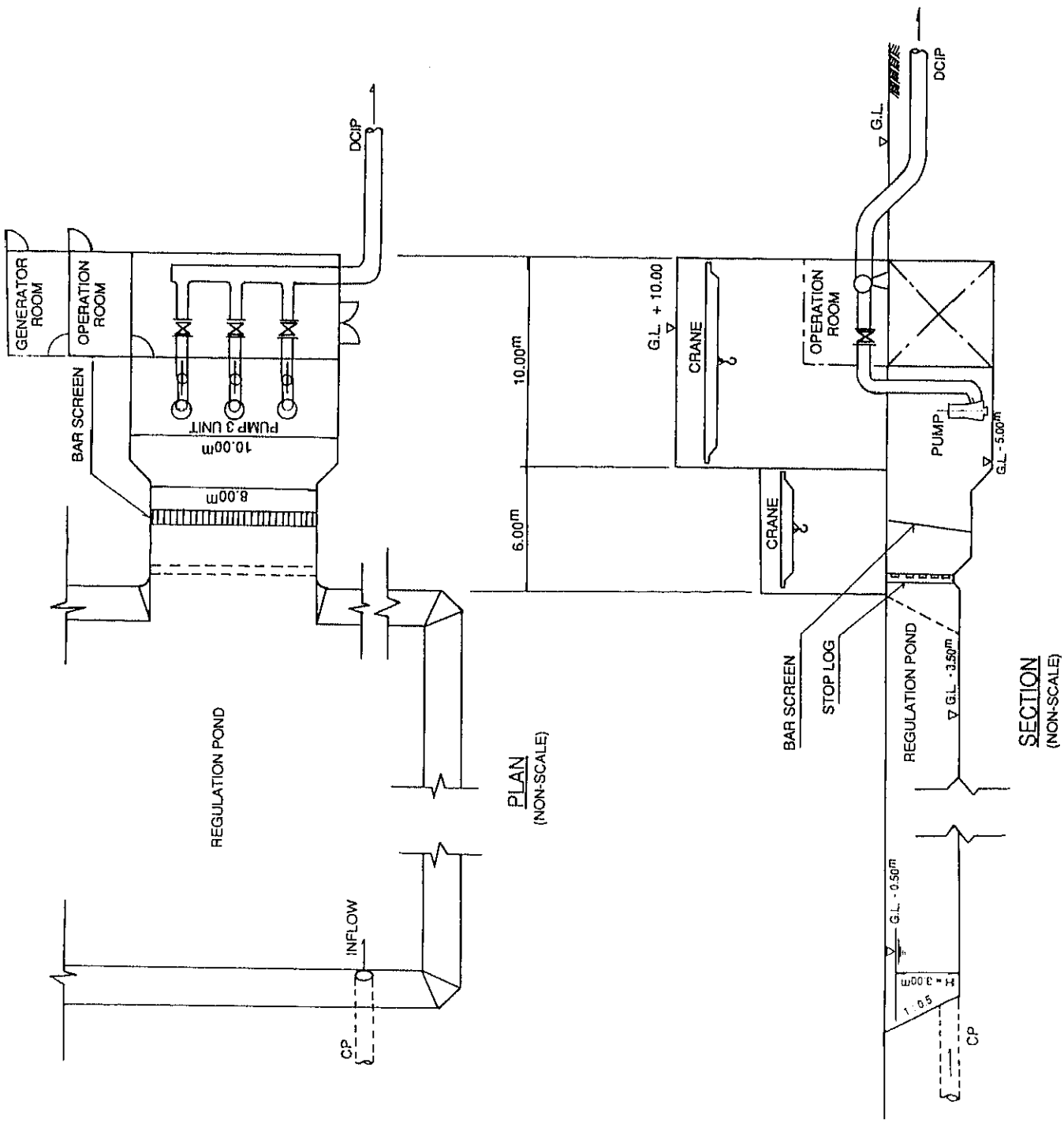
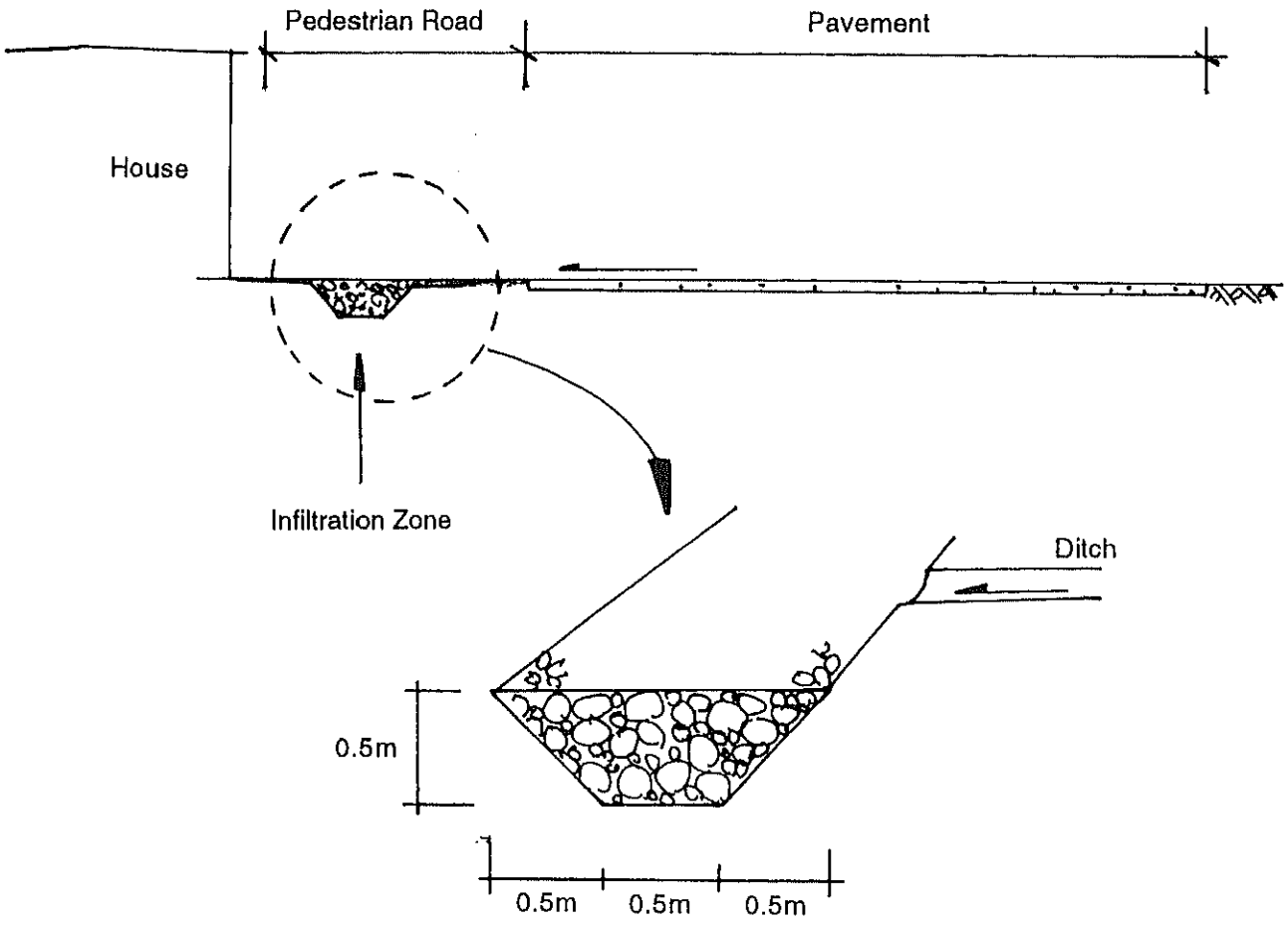


FIGURE 9.8 TYPICAL PLAN AND SECTION OF PROPOSED STORMWATER PUMPING STATION

(1) Along Road



(2) In House Garden

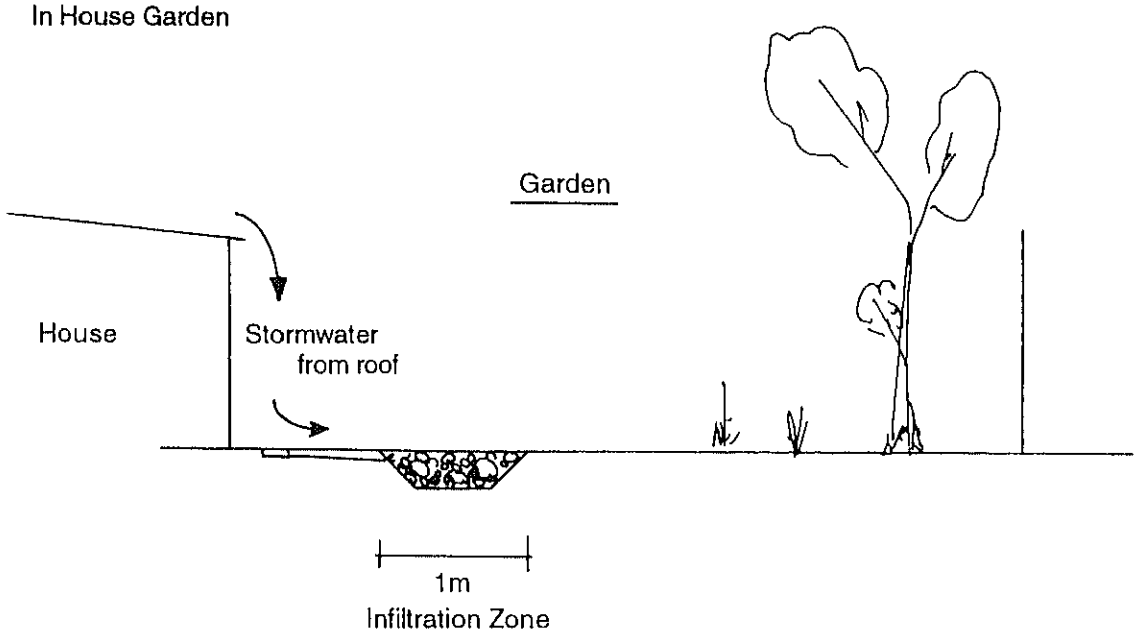
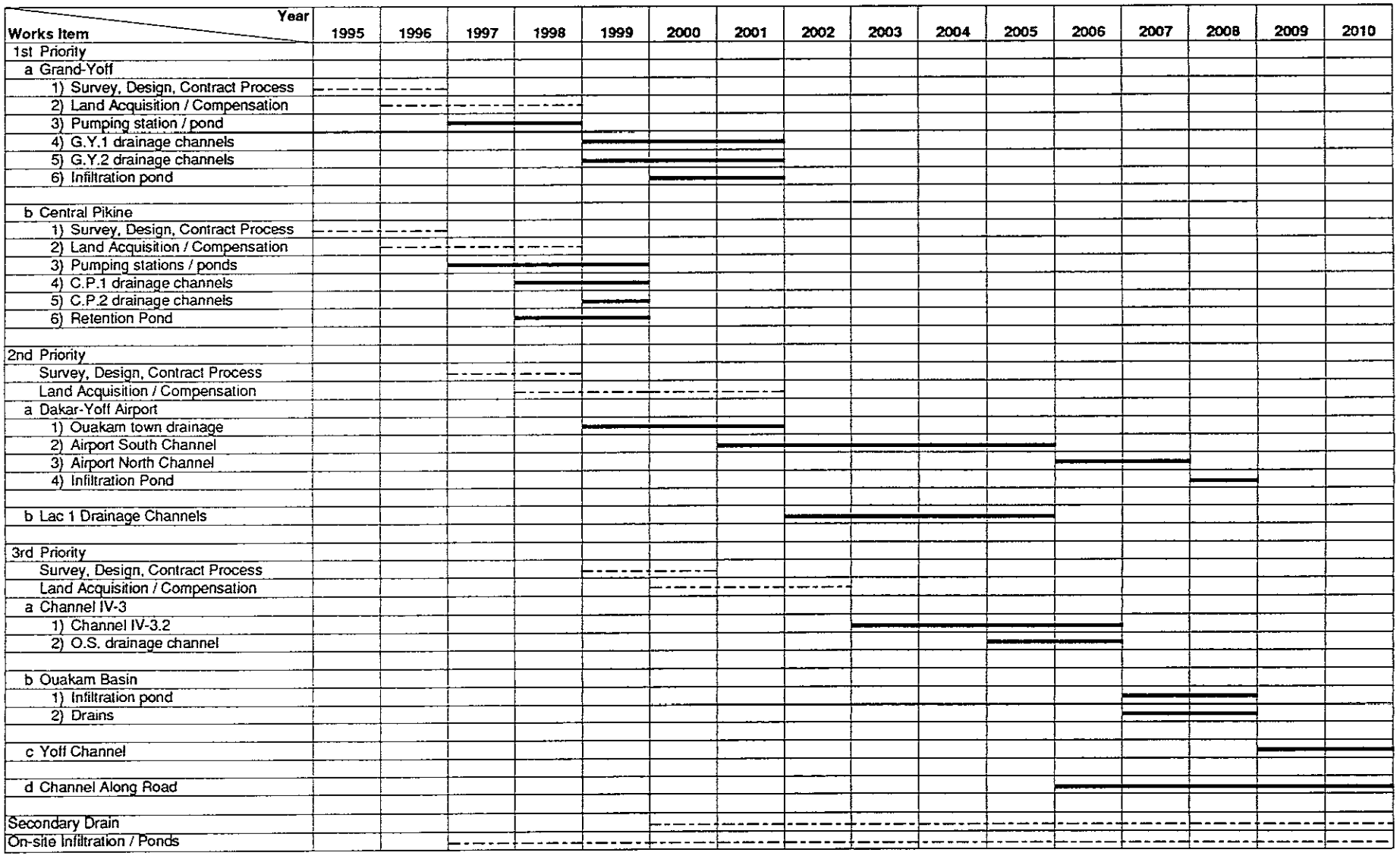


FIGURE 9.9 EXAMPLES OF INFILTRATION METHODS

FIGURE 9.10 IMPLEMENTATION SCHEDULE FOR STORMWATER DRAINAGE IMPROVEMENT PROJECT



CHAPTER 10

FEASIBILITY STUDY ON URBAN DRAINAGE OF PRIORITY PROJECT

CHAPTER 10 FEASIBILITY STUDY ON URBAN DRAINAGE OF PRIORITY PROJECT

10.1 PROJECT AREA

The feasibility study area covers the Central Pikine (C.P.) recommended by the Master Plan as the first priority area and a part of its surroundings and is shown in *Figure* 10.1. Total area for the feasibility study covers an area of 11.3 sq. km. Through discussion between the Senegalese side and the study team, the drainage channel proposed along the National Road, a part of main channels of the proposed pump drainage system, was included because of on-going development in its catchment area. Therefore, an area of E shown in Figure 10.1, which is a catchment of the drainage channel, is included to the feasibility study area. Areas of W and O are included to the feasibility study area with consideration of the location of pumping stations and drainage channels.

The study area consists of sandy areas and the topography is flat with the maximum elevation of 23 m. Areas lower than mean sea level are located in Thiaroye. The western urban area has four major lines of sand dunes with top elevations of 6 m to 12 m . The low strips (Niayes) between these sand dunes have ground elevations of 2 m to 9 m. Flood prone areas are located in the Niayes of eastern urban area having elevations of less than 4 m and in the low areas in Thiaroye having elevations of less than 2 m. Existing drainage conditions are shown in *Figure* 10.2.

10.2 DRAINAGE SYSTEM PLAN

10.2.1 Drainage Sub-Basin

The feasibility study area has been divided into 20 drainage sub-areas based on topographic conditions. The drainage sub-areas are shown in *Figure* 10.3 and details are given in *Table* 10.1.

10.2.2 Drainage Method

Since the stormwater discharged from the feasibility study area is impossible to drain to the sea or grand Niaye by gravity flow due to its topographic conditions, either drain by pumps or infiltration will be applied as drainage method for the area. The drainage sub-areas are classified as shown in *Figure* 10.4 by applicable drainage method.

10.2.3 Pump Drainage System

Two areas (C.P.1 and C.P.2) to be drained by pumps, as shown in *Figure* 10.4, exist independently from view points of topographic boundary and possible receiving body of stormwater. Therefore, an independent pump drainage system will be provided in each area.

The pump drainage system for C.P.1 is further divided into two systems considering topographic conditions and difference in development conditions in the area (Pikine Regular and Pikine Irregular).

Thus, three independent pump drainage systems: C.P.1-1 for Pikine Regular area, C.P.1-2 for Pikine Irregular and C.P.2 for Thiaroye, are proposed as follows:

1) Pikine Urban South (regular, C.P.1-1)

- Three (3) pumping stations with a pond at each site
- Drainage channels with a total length of 3,760 m

Figure 10.5 shows the proposed pump drainage system for C.P.1-1 pump drainage area.

2) Pikine Urban North (regular and irregular, C.P.1-2)

- Four (4) pumping stations with a pond at each site
- Drainage channels with a total length of 3,730 m

Figure 10.5 shows the proposed pump drainage system for C.P.1-2 pump drainage area.

3) Thiaroye (C.P.2)

- One pumping station with a pond
- Drainage channel along the National Road with a total length of 2,940 m
- Drainage channel to the pumping station with a total length of 770 m
- One retention pond with a total area of about 5.1 ha

Figure 10.6 shows the proposed pump drainage system for C.P.2 pump drainage area.

10.2.4 Areas to be Drained by Infiltration

For these areas, no particular structural measures are proposed, but the following non-structural measures are recommended from view point of urban drainage:

- Depressed areas in every independent catchment should be kept for infiltration/retention and on-site infiltration should be applied as much as possible.

- There are small scale possible flood areas in Pikine irregular area, having ground elevation of less than 4 m, in the north of the proposed pump drainage area. These areas should be reclaimed for easy infiltration when the areas are redeveloped.

- Wide low laying area is spread along the Rufisque Road and areas lower than 2 m and 1m in the north and south of the road respectively are flood prone. These areas should be reclaimed if developed.

- A depressed area located at the northern edge of the Central Pikine is an important place for drainage and should not be urbanized.

10.3 FACILITY PLAN

10.3.1 General

The facilities are planned based on the following strategic concepts:

- Precast concrete pipes for the drainage channels of the Pikine urban pump drainage area (C.P.1) are proposed because they are of small sizes.

- Concrete lined open channels for the main drainage channels of the Thiaroye pump drainage area (C.P.2) are proposed in principle because,

  - Proposed sites are not urbanized yet and land acquisition is not difficult.
  - Ease of maintenance
  - Lower cost than box culvert type, and other reasons.

  Comparison of the open channel and the box culvert types is shown in *Table* 10.2.

- Submergible type for the pumps is recommended taking the capacities and the required total heads into account. At least two units of pumps are proposed in one pumping station for ease of operation/maintenance and for economy. One generator having a capacity for driving one pump unit is proposed to provide. The generator will be used in emergency case when electricity is not available.

- Agricultural activity is considered in the planning of each retention pond.

- The drainage pipes are proposed to provide, in principle, along the roads with earth cover of about 1.0 m. Provision of pipes with large depth is avoided because of difficulty in construction and operation/maintenance. Therefore, a transmission pipe to lift the flood water by pumping to the highest point is proposed at each required site.

- Hydraulic requirements such as pump capacity, storage capacity of retention pond, size of storm sewer and drainage channel, etc. are calculated by the methods and criteria described in the Master Plan.

10.3.2 Main Features of Proposed Facilities

Main features of the proposed facilities are summarized in *Table* 10.3 and their layouts are shown in *Figure* 10.5 and 10.6. Typical designs of the facilities are shown in *Figure* 10.7 to 10.11.

10.4 CONSTRUCTION PLAN AND COST ESTIMATE

10.4.1 General

Construction works for the drainage project consists of earth works, concrete works, pipe works, mechanical/electrical works for the pumping stations and other miscellaneous works. These works will be executed by ordinary methods of construction using construction equipment available in Senegal. This will facilitate equipment maintenance and supply of spare parts as well.

Major works are planned to be carried out by mechanical power. However, in order to enhance employment opportunity, man power will be used to the maximum extent wherever possible.

10.4.2 Construction Plan

1) Construction Method

Construction methods of major works are expected as follows:

- Excavation of retention ponds
- Excavation for storm sewers
- Installation of precast concrete pipes for storm sewers
- Back filling of soil for storm sewers
- Excavation of drainage open channels
- Concrete casting

2) Required Construction Period

Construction period will depend on rainfall and holidays. In Dakar, however, number of rainy days with depth of more than 10 mm in one year is only about 20 days. Therefore, yearly workable days for construction are large in number.

Required construction period for each work is estimated as follows:

Pikine Urban South System (C.P. 1-1) :

Pumping stations:	6 months
Retention ponds:	6 months
Drainage pipes:	12 months

Pikine Urban North System (C.P. 1-2) :

Pumping stations:	6 months
Retention ponds:	6 months
Drainage pipes:	12 months

Thiaroye System (C.P. 2) :

Pumping station:	12 months
Retention Ponds:	24 months
Drainage channels:	18 months

3) Sequence of works is proposed as follows:

- The facilities should be constructed from the downstream toward the upstream.
- The pumping stations in one drainage system should be constructed at the same time for convenience of installation and training.
- Storm sewers flowing into the sub-pumping stations should be constructed later.

10.4.3 Cost Estimate

1) Basis of Cost Estimate

The project cost consists of (1) construction cost, (2) land acquisition/compensation cost, (3) administration cost, (4) engineering service cost and (5) physical contingency and is estimated based on the following conditions:

- All costs are expressed under the economic conditions that prevailed in March 1994.
- The exchange rates of currencies are as follows:
  FF 1=FCFA 100
- The cost is classified into foreign and local currency portions and the rates of currency portion estimated in the Master Plan are applied.
- Administration cost is assumed to be 1.5 % of the total of construction and land acquisition/ compensation costs.
- Engineering cost is assumed to be 7 % of the total of construction cost .
- Physical contingency is assumed to be 10 % of the total of construction, land acquisition/compensation, administration and engineering service costs.
- Price escalation is not counted.

2) Cost Estimate

The construction cost is estimated by multiplying the quantity of work (*Table* 10.4) by unit price based on the data obtained from SONEES, Ministry of Hydraulics and other agencies.

The unit prices include site expenses, contractors overhead, profit and tax. Unit prices and construction costs are shown in *Table* 10.5.

The total project cost, including land acquisition/compensation cost, engineering service, government administration and physical contingency, is estimated at FCFA 10,647 million consisting of the local currency portion of FCFA 4,770 million and foreign currency portion of FCFA 5,877 million at March 1994 prices as shown below. Breakdown of the project cost is given in *Tables* 10.6 and 10.7.

Item	Total FCFA (1000 FCFA)	Local Currency Portion (1000FCFA)	Foreign Currency Portion (1000FCFA)
Direct Construction Cost (DCC)	8,686,730	3,235,077	5,451,653
Land Acquisition	250,800	250,800	0
Engineering Service	608,071	182,421	425,650
Government Administration	134,063	134,063	0
Physical Contingency	967,966	967,966	0
Total	10,647,630	4,770,327	5,877,303

Annual operation and maintenance cost of the project facilities after construction is assumed to be 0.5 % of the construction cost.

Items	1000 FCFA	
Direct Construction Cost (DCC)	8,686,730	
Land Acquisition	250,800	
Engineering Service	608,071	(7 % of DCC)
Government Administration	134,063	(1.5 % of DCC)
Physical Contingency	967,966	(10 % of DCC)
Total	10,647,630	

10.5 IMPLEMENTATION PROGRAM

Sequence of the construction works is planned considering the construction plan described in the previous section.

Proposed implementation schedule of the project works is shown in *Figure* 10.12.

Annual disbursement of the required project cost is prepared based on the implementation schedule as shown in *Table* 10.8

10.6 MANAGEMENT OF THE PROJECT

The proposed new organization and institution for urban drainage project are considered to be basically applied during construction stage of this project. After completion of construction of the facilities, following organization is proposed for operation/maintenance.

The urban drainage networks under the priority project can be divided into three systems, i.e. Pikine Urban South System, Pikine Urban North System and Thiaroye System.

It is recommended that site offices be established to manage those systems. One site office will take care of one drainage system. Therefore, there will be three site offices.

Manpower required for the management of drainage facilities such as drainage channels (storm sewers, transmission pipes and open channels) and pumping stations is proposed as follows:

Item	Chief	Sub-Chief	Workers	Driver	Total
1. Pikine Urban North System	1	1	2	1	5
2. Pikine Urban South System	1	1	2	1	5
3. Thiaroye System	1	1	2	1	5
4. Overheads					2
TOTAL					17

The eligibility of the chief and sub-chief will be engineer. One vehicle will be stationed in each site office to be used essentially for operation and maintenance of the facilities. Office personnel will come from both CUD and SONEES or from a new organization.

10.7 PROJECT EVALUATION

10.7.1 General

The proposed urban drainage project for Central Pikine area is evaluated as follows:

The project is technically sound without any difficulty in construction, and no serious problem is expected in drainage function of the facilities and in operation/maintenance.

10.7.2. Environmental Evaluation

Negative impacts to noise/vibration conditions and traffic in the vicinity of construction sites would be unavoidable during the construction phase. However, any of such impacts would be limited to short time and to small areas. Although construction of pumping stations and retention ponds may require land acquisition, since sites for these facilities have been selected in wet lands, residential areas discarded due to repeated inundation and vacant place in public facilities, any particular problems are not foreseen.

Following impacts are concerned during operation phase:

- Pumping Stations: Noise and vibration: Operation will be of very low frequency and short every time.

- Retention Ponds: Deprivation of farming land: Retention ponds impound water only in heavy rains. They are dried up in other period, therefore, can be opened to people who want to cultivate.

As such, limited negative impacts by the project are expected, but they are considered to be very minor.

10.7.3. Economic Evaluation

Economic evaluation is carried out based on the economic costs and economic benefits calculated by the same method applied to the Master Plan Study. The results are as follows:

Net Present Value (NPV):	430 million FCFA
Benefit Cost Ratio (B/C):	1.07
Economic Internal Rate of Return (EIRR):	10.8 %

The project is judged to be economically feasible.

10.8 RECOMMENDATION

Immediate construction of the facilities is recommended in consideration of serious flood problem.

The following non-structural measures are also recommended to support the proposed structural measures and to achieve successful drainage of the project area.

- Drainage of all areas having elevation of higher than 4 m should be done by infiltration, in principle. The depressed area in each closed catchment area, except the proposed pump drainage areas, should be kept for infiltration/ retention, and on-site infiltration should be applied in high areas.

- In relation to Technopole development, an open channel for drainage of a part of Pikine urban and Technopole project areas into Grand Niaye should be provided. Excavated soils during construction of the channel can be used for reclamation of the Technopole area.

- There have small scale flood prone areas in Pikine irregular area located in the north of the pump drainage area. These areas should be slightly reclaimed for easy infiltration when the areas will be redeveloped.

- Areas with elevation of less than 2 m and 1 m in the north and the south of the Rufisque Road respectively are flood prone. These areas, except the proposed retention pond areas, should be reclaimed if developed.

- A depressed area located at the northern edge of the project area is an important land for drainage and should not be urbanized.

- Operation and maintenance of the proposed drainage facilities will be done by the proposed new organization. A part of the work is recommended to be done under participation of the residents in the flood prone areas who are the direct beneficiaries of the project. Such work items are as follows:

- Maintenance work of the drainage channels in the flood prone areas such as cleaning of the channels before rainy season, preventive activities to keep the channels clean, etc.

- Management of the retention ponds by the farmers who have agricultural activities in the pond areas.

TABLES AND FIGURES

TABLE 10.1 SUMMERY OF FEASIBILITY STUDY AREA (km^2)

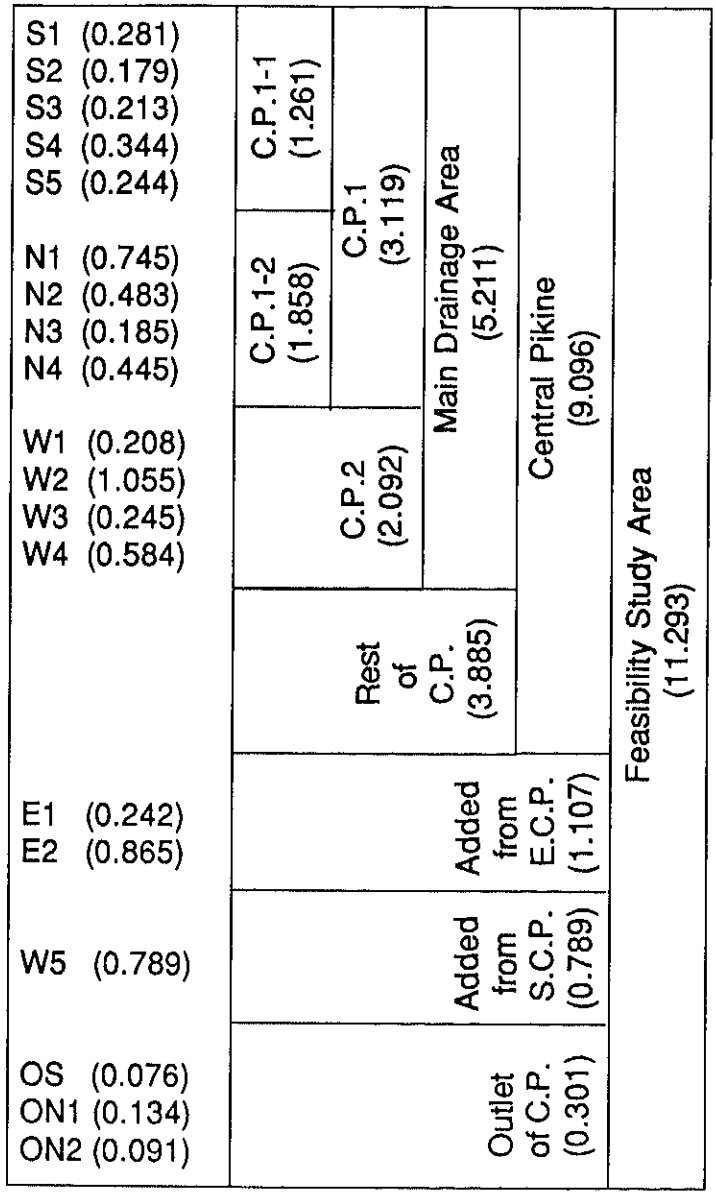
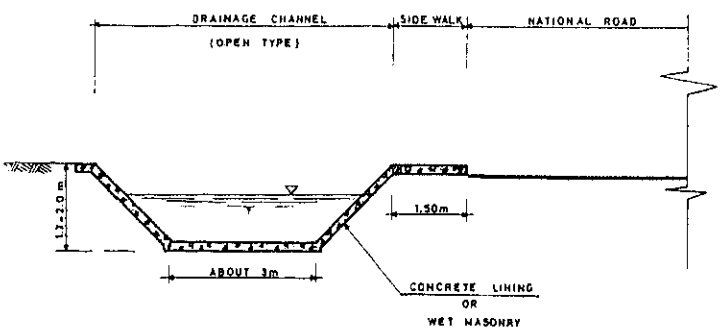


TABLE 10.2 COMPARISON OF ALTERNATIVE STRUCTURAL TYPE FOR DRAINAGE CHANNEL ALONG THE RUFISQUE ROAD

	OPEN CHANNEL	BOX CULVERT
1 Construction		
1) Cost	331,000 FCFA/m (Low)	1,794,000 FCFA/m (High)
2) Ease of Work	Easy and short	Long period
2 Maintenance		
1) Cost	Low	High
2) Sureness	High	Low
3 Land Acquisition		
1) Cost	11,550 FCFA/m	13,200 FCFA/m
2) Social problem	Not serious	Not serious
4 Compensation		
1) Cost	11,550 FCFA	13,200 FCFA
2) Sureness	Not serious	Not serious
5 Safety		
1) Against flood	High	Medium
2) For Traffic	Medium	High
6 Flexibility for future urbanization	High	Low

COMPARISON OF ALTERNATIVES FOR DRAINAGE CHANNEL ALONG THE NATIONAL ROAD

ALTERNATIVE I
(OPEN CHANNEL)



ALTERNATIVE II
(BOX CULVERT)

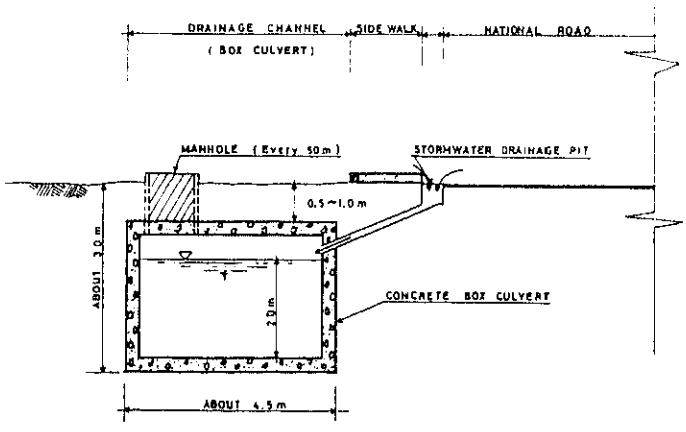


TABLE 10.3 SUMMARY OF PROPOSED FACILITY

Area	Proposed Facilities			Total
CP 1	Drain to Grand Niaye			
	Construction of Storm Sewer		2 Systems Total	L= 4,460 m
		C.P.1-1		(L=2,970m)
			d=1,100mm CP	(250m)
			d=1,000mm CP	(1,050m)
			d=900mm CP	(620m)
			d=800mm CP	(1,050m)
		C.P.1-2		(L=1,490m)
			d=1,100mm CP	(260m)
			d=1,000mm CP	(550m)
			d=600mm CP	(680m)
	Construction of open channel (2m x 0.4 - 0.6m, 1)		2 Systems Total	L = 400m
		C.P.1-1		(100 m)
		C.P.1-2		(300 m)
	Stormwater Pumping Station		2 Systems Total	7 pls
	C.P.1-1 (1.0 m3/s 2pls, 0.3 m3/s 1pls)			3 pls
	C.P.1-2 (1.5 m3/s , 1.0 m3/s, 0.5m3/s, 0.3m3/s)			4 pls
	Stormwater Transmission Pipe (Ductile Iron Pipe)		2 Systems Total	L= 2,630m
		C.P. 1-1		(L=690m)
			d=600mm DCIP	(420m)
			d=800mm DCIP	(270m)
		C.P. 1-2		(L=1,940m)
			d=600mmDCIP	(570m)
			d=1100mm DCIP	(920m)
			d=801mm DCIP	(450m)
CP 2	Drain to Sea			
	Construction of main Drainage Channel (1-3m x 0.4-1.6m, 1)			L = 2,940 m
	Improvement of Existing Drainage Channel (3m x 0.9m, 1)			L= 770 m
	Stormwater Pumping Station (1.5 m3/s)			1 Place
	Retention Pond		Total	5 .1ha

TABLE 10.4 UNIT PRICE/COST FOR WORK ITEMS

Item	Unit	Unit Price/Cost (FCFA)
Concrete Lining Open Channel		
Type F-1 (Bottom Width=3m)	m	311,000
Type F-2 (Bottom Width=2m)	m	196,000
Type F-3 (Bottom Width=1m)	m	162,000
Storm Sewer		
Type F-1 (d=600mm Concrete Pipe)	m	316,000
Type F-2 (d=800mm Concrete Pipe)	m	378,000
Type F-3 (d=900mm Concrete Pipe)	m	413,000
Type F-4 (d=1,000mm Concrete Pipe)	m	466,000
Type F-5 (d=1,100mm Concrete Pipe)	m	525,000
Retention Pond	ha	42,500,000
Stormwater Pumping Station		
Type F-1 (1.5m3/s)	pls	395,900,000
Type F-2 (1.0m3/s)	pls	311,800,000
Type F-3 (0.5m3/s)	pls	242,800,000
Type F-4 (0.3m3/s)	pls	209,800,000
Transmission Pipe Line		
Type F-1 (d=600mm Ductile Iron Pipe)	m	283,700
Type F-2 (d=800mm Ductile Iron Pipe)	m	387,300
Type F-3 (d=1,100mm Ductile Iron Pipe)	m	608,600
Land Acquisition	m2	1,650

TABLE 10.5 WORK VOLUME (FEASIBILITY STUDY)

Item	Unit	Work Volume C.P.1-1	C.P.1-2	C.P.2	Total
Concrete Lining Open Channel					
Type F-1 (Bottom Width=3m)	m			2,710	2,710
Type F-2 (Bottom Width=2m)	m	100	300	300	700
Type F-3 (Bottom Width=1m)	m			700	700
Storm Sewer					
Type F-1 (d=600mm Concrete Pipe)	m		680		680
Type F-2 (d=800mm Concrete Pipe)	m	1,050			1,050
Type F-3 (d=900mm Concrete Pipe)	m	620			620
Type F-4 (d=1,000mm Concrete Pipe)	m	1,050	550		1,600
Type F-5 (d=1,100mm Concrete Pipe)	m	250	260		510
Retention Pond	ha	1.2	1.3	5.1	7.6
Stormwater Pumping Station					
Type F-1 (1.5m3/s: 0.5m3/sx3sets)	pls		1	1	2
Type F-2 (1.0m3/s: 0.33m3/sx3sets)	pls	2	1		3
Type F-3 (0.5m3/s: 0.25m3/sx2sets)	pls		1		1
Type F-4 (0.3m3/s: 0.15m3/sx2sets)	pls	1	1		2
Transmission Pipe Line					
Type F-1 (d=600mm Ductile Iron Pipe)	m	270	920		1,190
Type F-2 (d=800mm Ductile Iron Pipe)	m	420	570		990
Type F-3 (d=1,100mm Ductile Iron Pipe)	m		450		450
Land Acquisition	m2	12,000	13,000	51,000	76,000

TABLE 10.6 CONSTRUCTION COST (FEASIBILITY STUDY)

Item	Unit Price/Cost (FCFA)	Unit	Construction Cost (x1000 FCFA) C.P.1-1	C.P.1-2	C.P.2	Total
I. Direct Construction Cost						
1. Concrete Lining Open Channel						
Type F-1 (Bottom Width=3m)	311,000	m			842,810	842,810
Type F-2 (Bottom Width=2m)	196,000	m	19,600	58,800	58,800	137,200
Type F-3 (Bottom Width=1m)	162,000	m			113,400	113,400
2. Storm Swer						
Type F-1 (d=600mm Concrete Pipe)	316,000	m		214,880		214,880
Type F-2 (d=800mm Concrete Pipe)	378,000	m	396,900			396,900
Type F-3 (d=900mm Concrete Pipe)	413,000	m	256,060			256,060
Type F-4 (d=1,000mm Concrete Pipe)	466,000	m	489,300	256,300		745,600
Type F-5 (d=1,100mm Concrete Pipe)	525,000	m	131,250	136,500		267,750
3. Retention Pond	42,500,000	ha	51,000	55,250	216,750	323,000
4. Stormwater Pumping Station						
Type F-1 (1.5m3/s)	395,900,000	pls		395,900	395,900	791,800
Type F-2 (1.0m3/s)	311,800,000	pls	623,600	311,800		935,400
Type F-3 (0.5m3/s)	242,800,000	pls		242,800		242,800
Type F-4 (0.3m3/s)	209,800,000	pls	209,800	209,800		419,600
5. Transmission Pipe Line						
Type F-1 (d=600mm Ductile Iron Pipe)	283,700	m	76,599	261,004		337,603
Type F-2 (d=800mm Ductile Iron Pipe)	387,300	m	162,666	220,761		383,427
Type F-3 (d=1,100mm Ductile Iron Pipe)	608,600	m		273,870		273,870
6. Secondery Drain		L.S.	725,033	791,300	488,298	2,004,630
Sub-Total			3,141,808	3,428,965	2,115,958	8,686,730
II. Land Acquisition and Compensation						
1. Land Acquisition	1,650	m2	19,800	21,450	84,150	125,400
2. Compensation	1,650	m2	19,800	21,450	84,150	125,400
Sub-Total			39,600	42,900	168,300	250,800
III. Engineering Service	7% of I		219,927	240,028	148,117	608,071
IV. Government Administration	1.5% of I + II		47,721	52,078	34,264	134,063
V. Physical Contingency	10% of (I to IV)		344,906	376,397	246,664	967,966
VI. Project Cost			3,793,961	4,140,367	2,713,303	10,647,630

TABLE 10.7 BREAKDOWN OF CONSTRUCTION COST (FEASIBILITY STUDY)

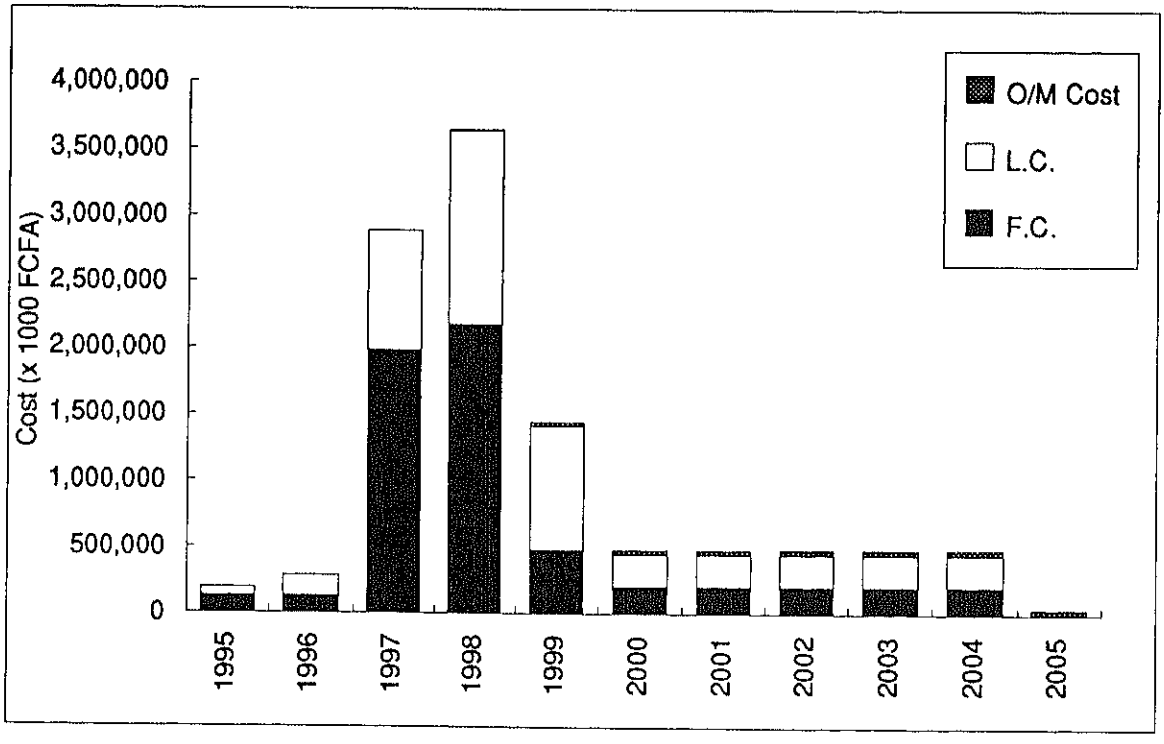
	CONSTRUCTION COST		
	FC	LC	TT
CP-1 and CP-2			
Engineering Service	425,650	182,421	608,071
Land Acquisition / Compensation	0	250,800	250,800
CP-1 Drainage System			
System-S			
Pumping Stations	625,050	208,350	833,400
Transmission Pipe	203,375	35,890	239,265
Storm Sewer	1,082,484	191,027	1,273,510
Drainage Channel	2,940	16,660	19,600
Retention Pond	7,650	43,350	51,000
System-N			
Pumping Stations	870,225	290,075	1,160,300
Transmission Pipe	642,290	113,345	755,635
Storm Sewer	516,528	91,152	607,680
Drainage Channel	8,820	49,980	58,800
Retention Pond	8,288	46,963	55,250
Sub-total of CP1	3,967,649	1,086,791	5,054,440
CP-2 Drainage System			
Pumping Station	296,925	98,975	395,900
Drainage Channel	152,252	862,759	1,015,010
Retention Pond	32,513	184,238	216,750
Sub-total of CP2	481,689	1,145,971	1,627,660
Secondary Drain	1,002,315	1,002,315	2,004,630
Government Administration	0	134,063	134,063
Physical Contingency	0	967,966	967,966
Project Cost	5,877,303	4,770,328	10,647,630
Operation and Maintenance	0	270,122	
Grand Total	5,877,303	5,040,450	10,917,752

Unit : x 1000 FCFA

TABLE 10.8 COST DISBURSEMENT SCHEDULE (FEASIBILITY STUDY)

	Construction Cost			O/M Cost	Total
	F.C.	L.C.	Sub-Total		
1995	121,614	69,494	191,108		191,108
1996	121,614	162,833	284,447		284,447
1997	1,982,306	904,917	2,887,223		2,887,223
1998	2,173,964	1,458,636	3,632,600	12,084	3,644,684
1999	475,489	938,593	1,414,083	27,506	1,441,589
2000	200,463	247,171	447,634	33,411	481,044
2001	200,463	247,171	447,634	35,415	483,049
2002	200,463	247,171	447,634	37,420	485,054
2003	200,463	247,171	447,634	39,424	487,058
2004	200,463	247,171	447,634	41,429	489,063
2005	0	0	0	43,434	43,434
Total Cost (1995-2010)	5,877,303	4,770,328	10,647,630	270,122	10,917,752

Unit : x 1000 FCFA



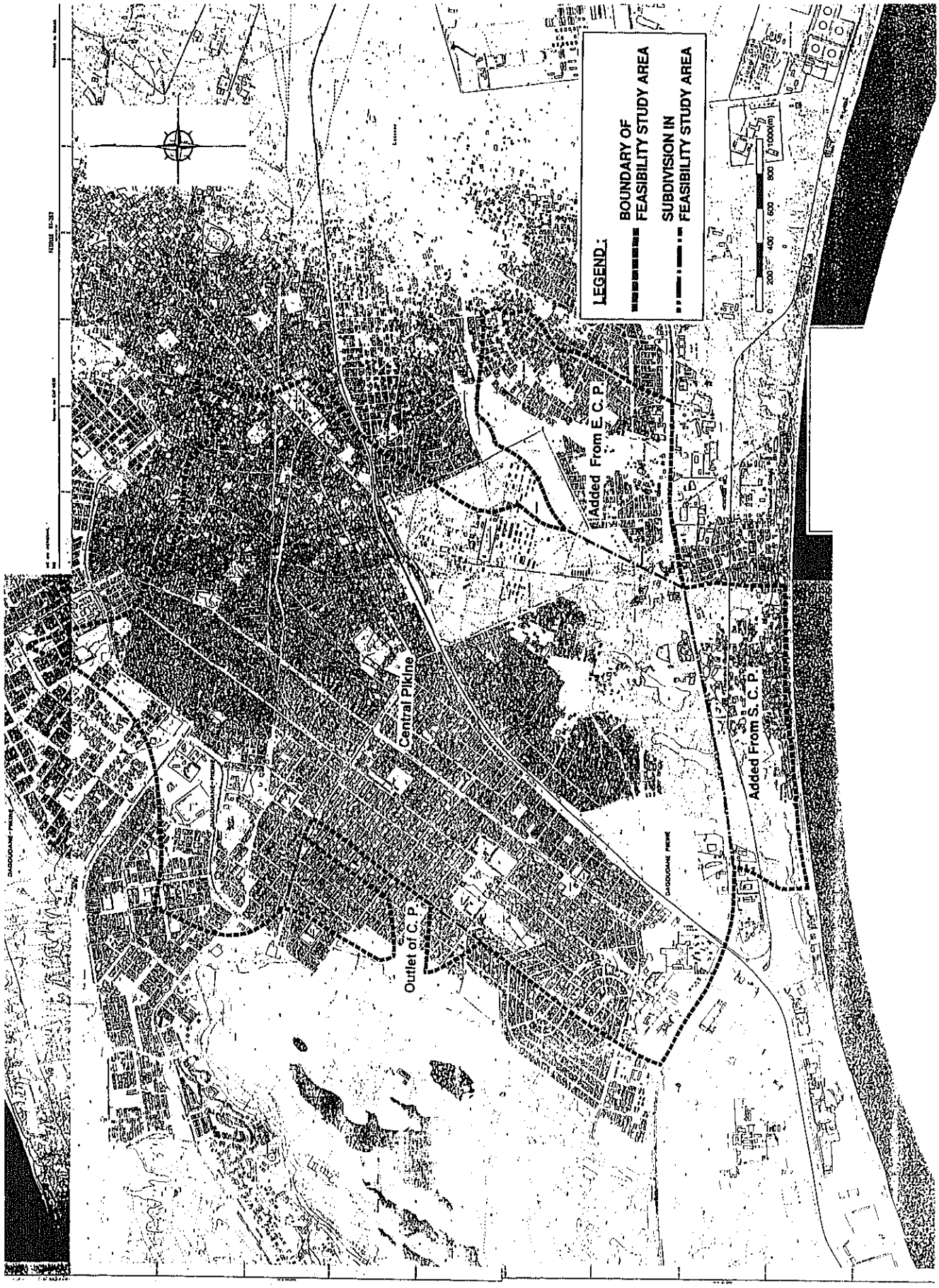


FIGURE 10.1 FEASIBILITY STUDY AREA

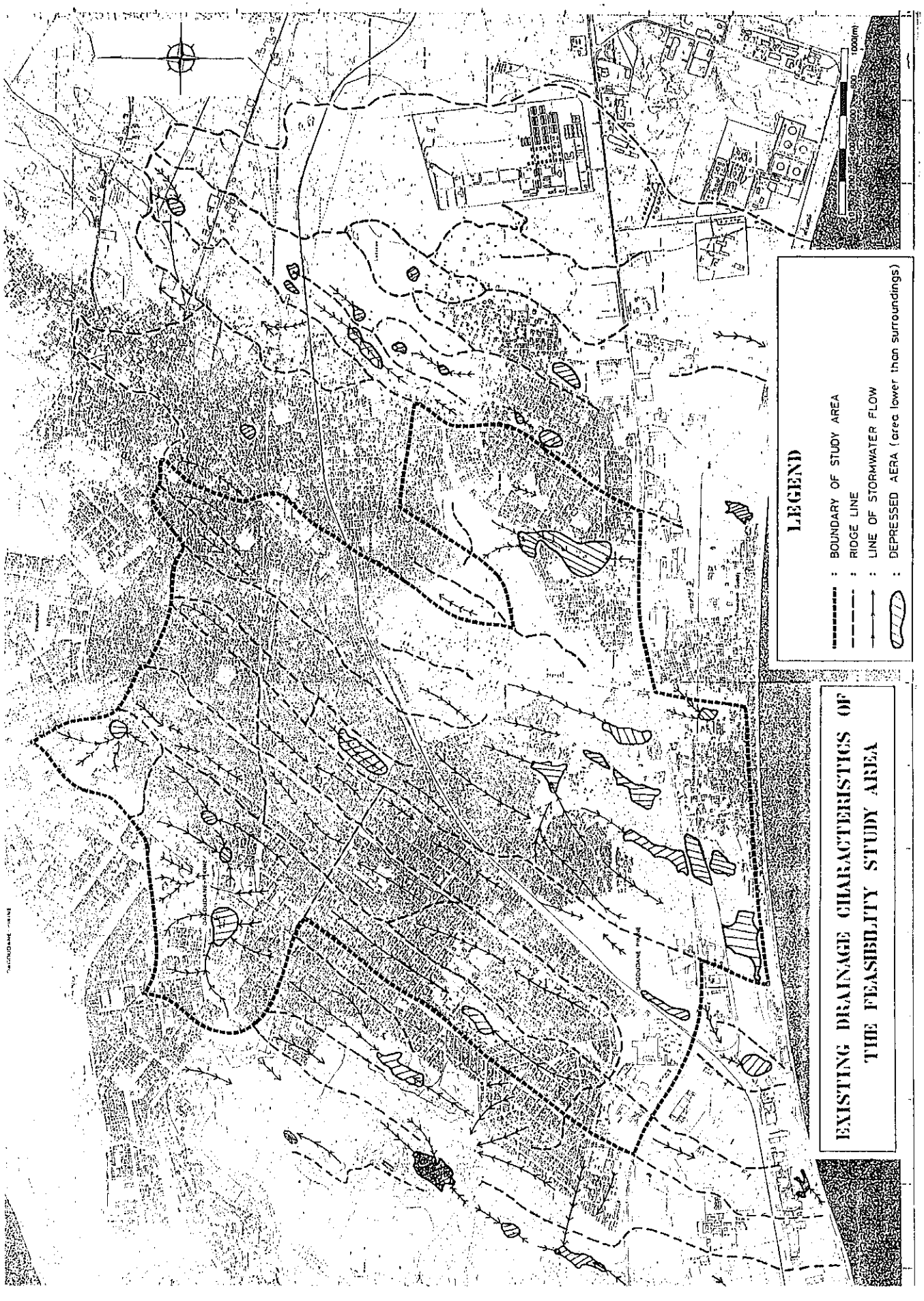


FIGURE 10.2 EXISTING DRAINAGE CONDITION

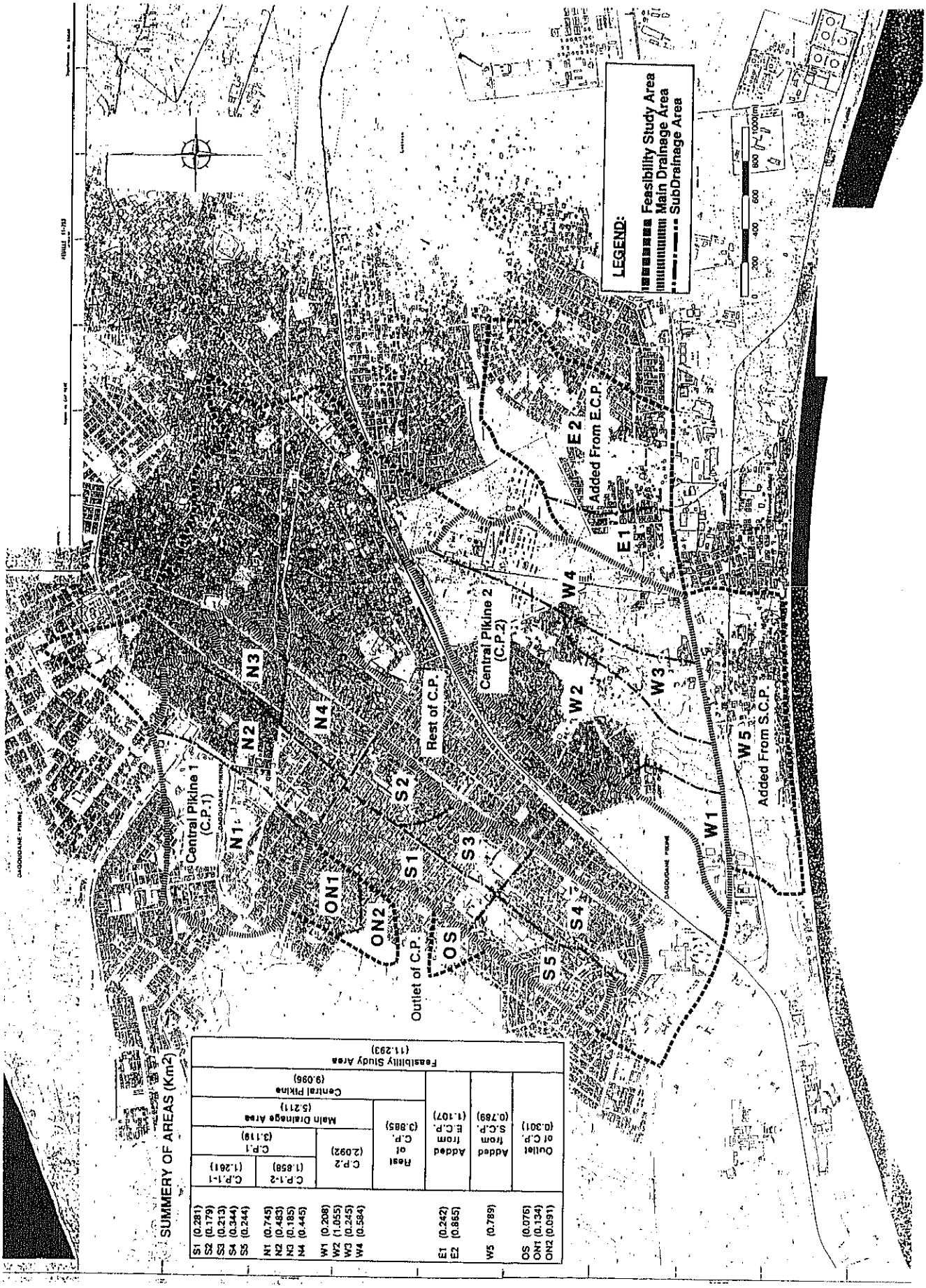


FIGURE 10.3 DRAINAGE SUB-AREAS

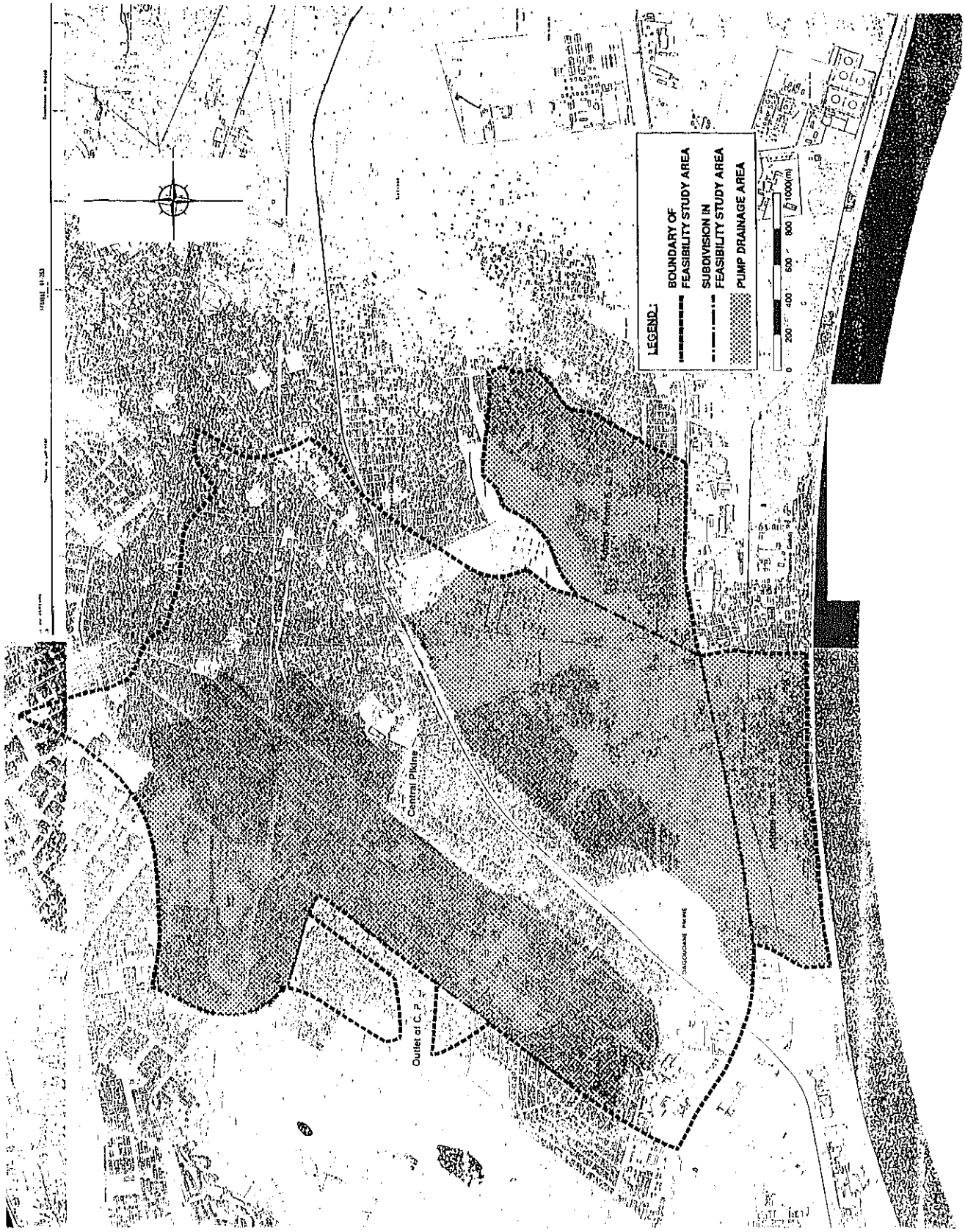


FIGURE 10.4 CLASSIFIED PUMP DRAINAGE AREA

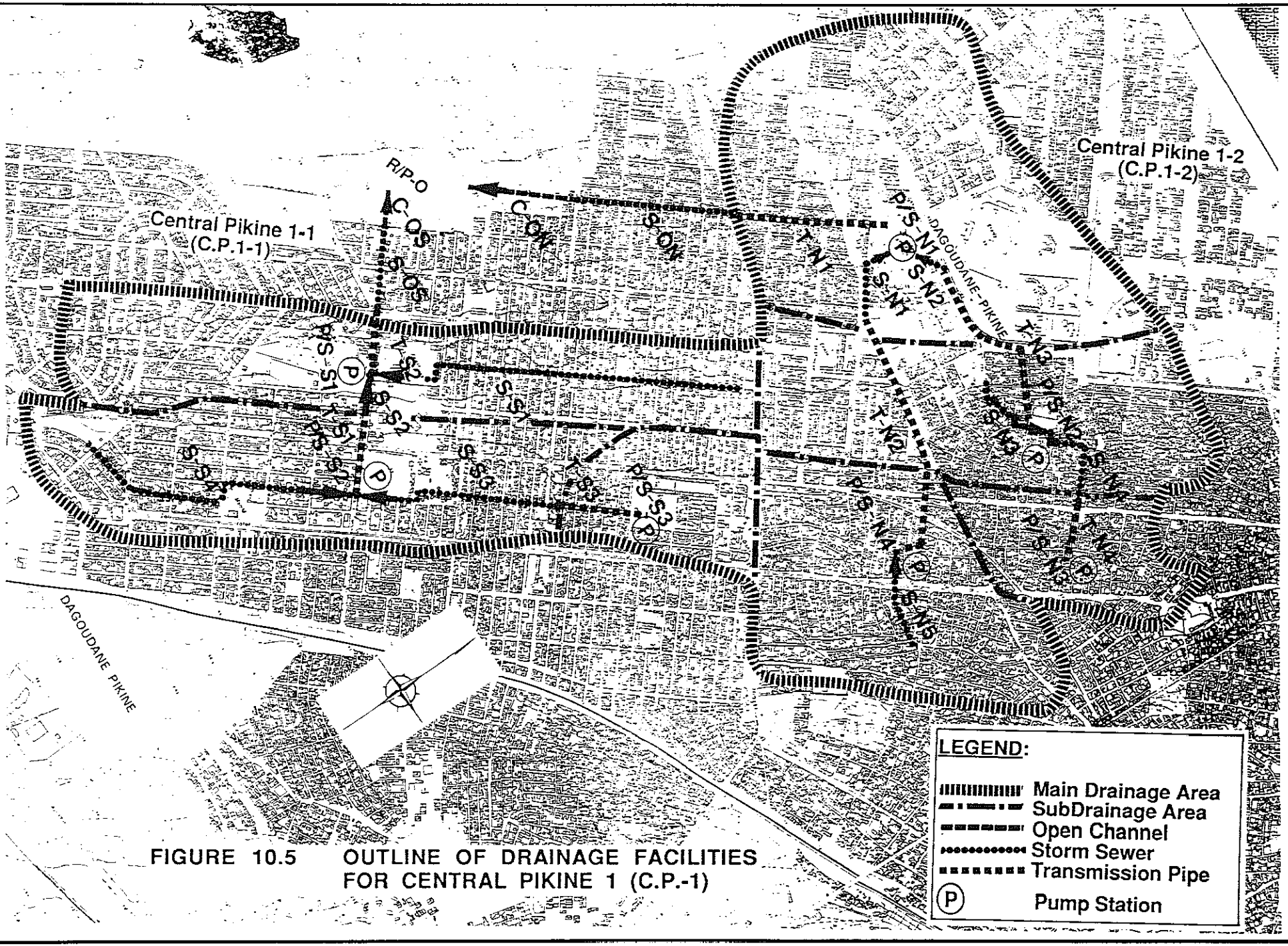


FIGURE 10.5 OUTLINE OF DRAINAGE FACILITIES FOR CENTRAL PIKINE 1 (C.P.-1)

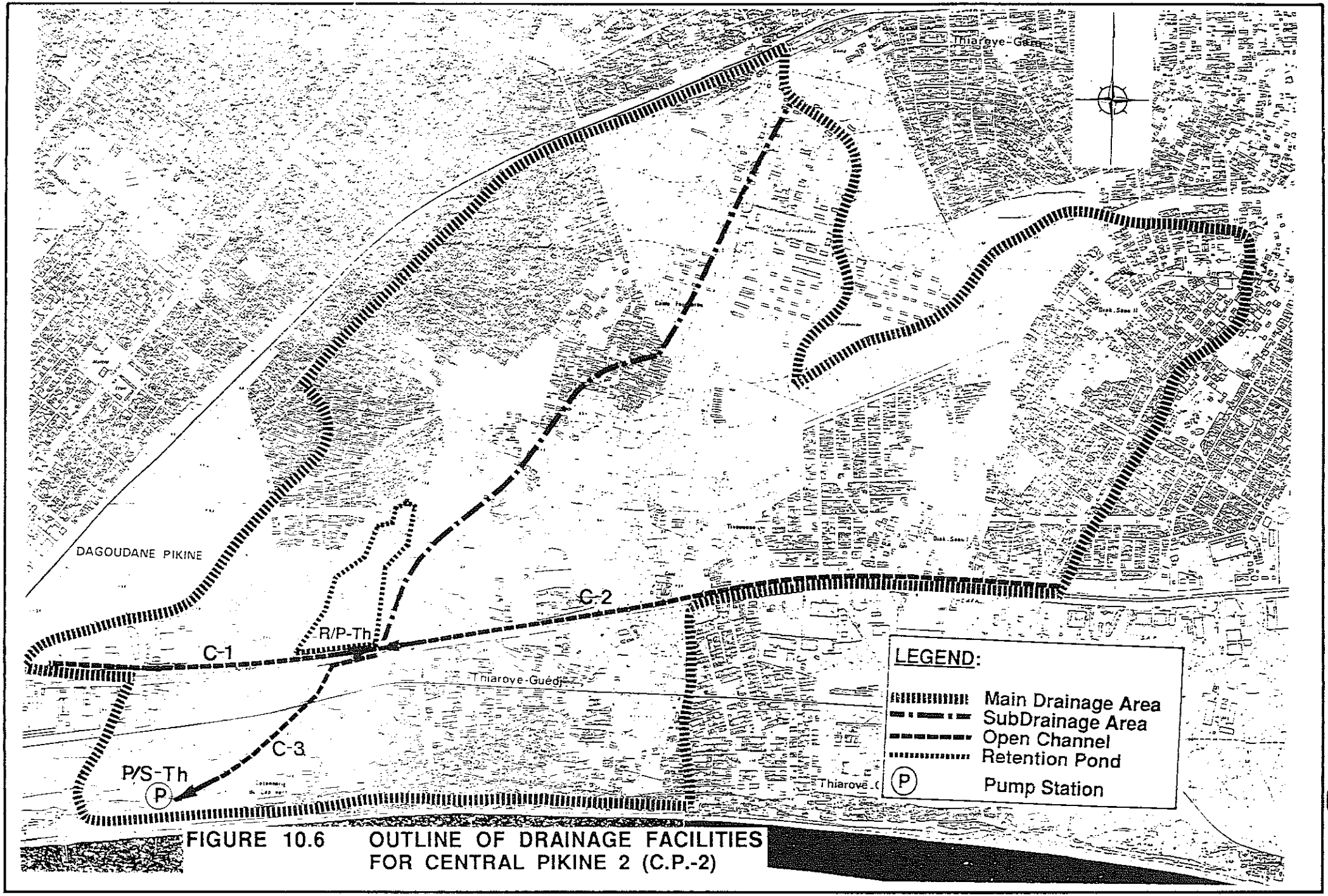
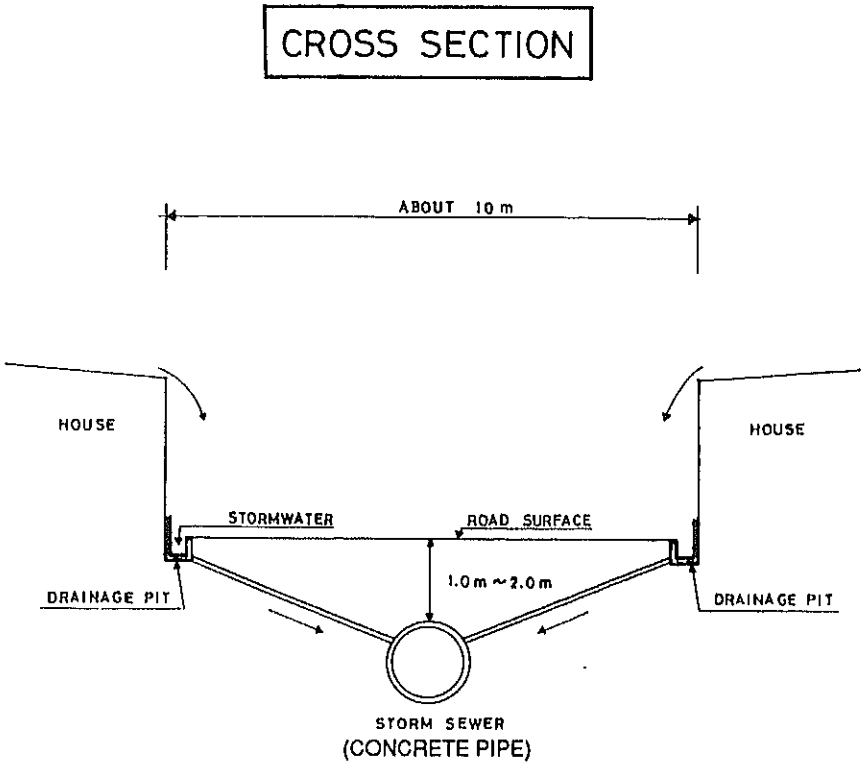


FIGURE 10.6 OUTLINE OF DRAINAGE FACILITIES FOR CENTRAL PIKINE 2 (C.P.-2)



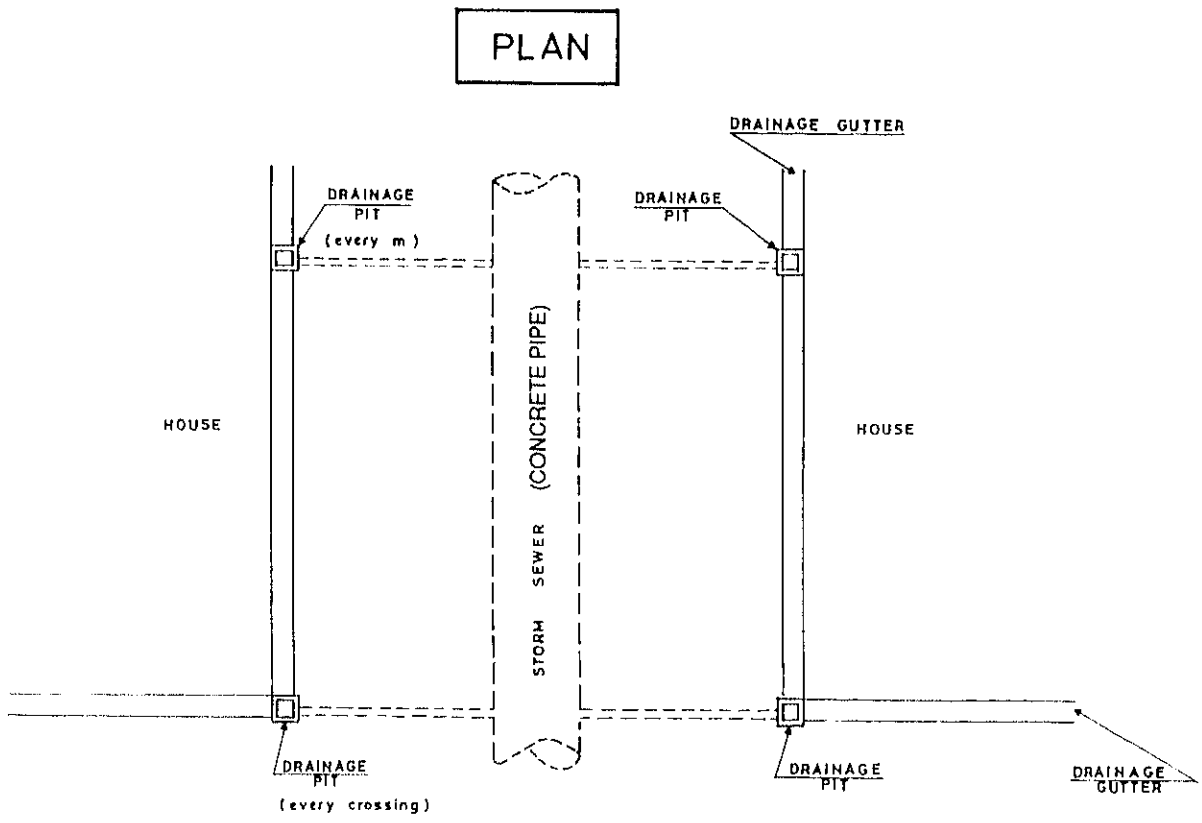
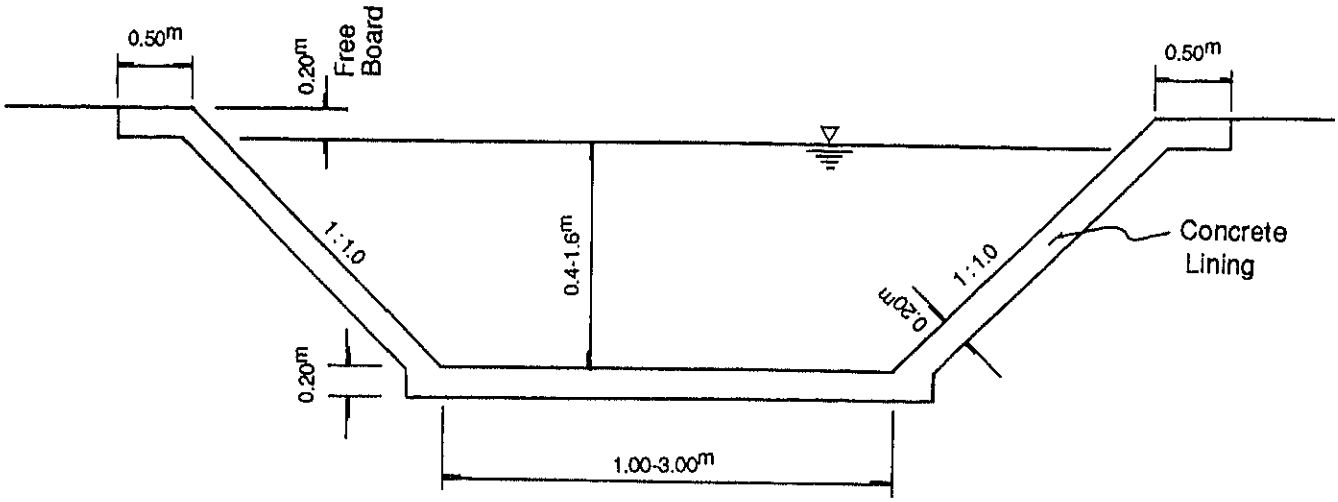
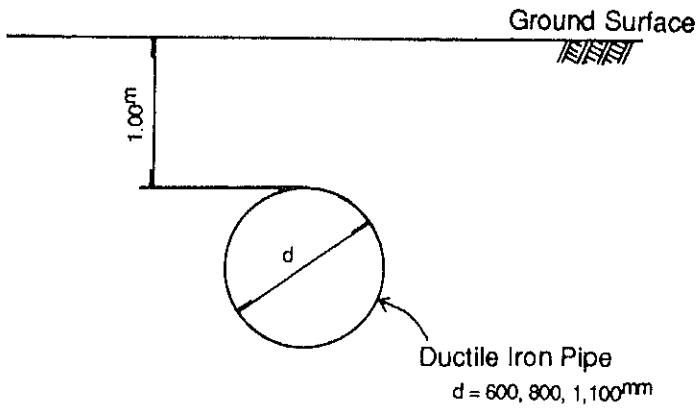


FIGURE 10.7 TYPICAL DESIGN OF STORM SEWER

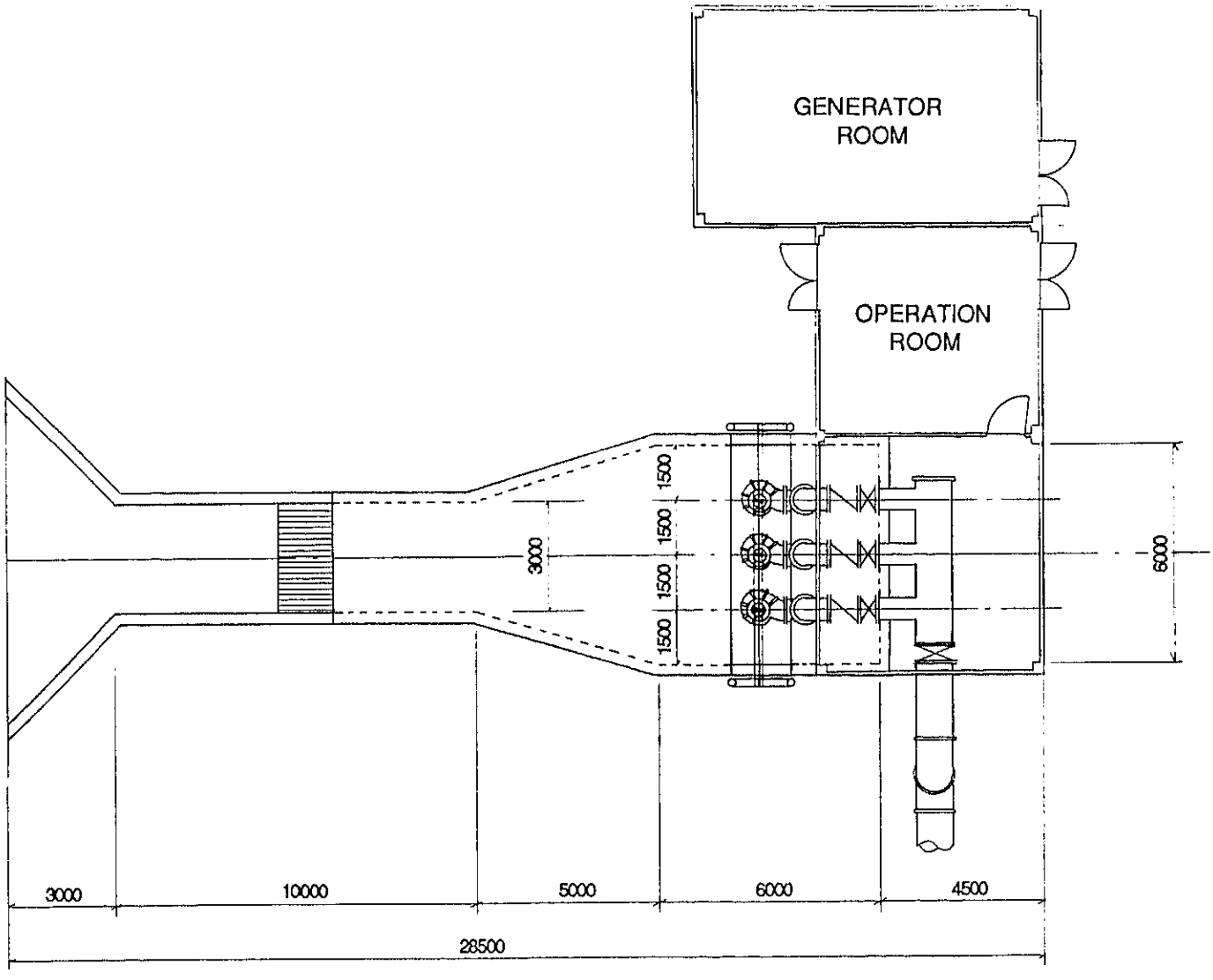


Main Drainage Channel

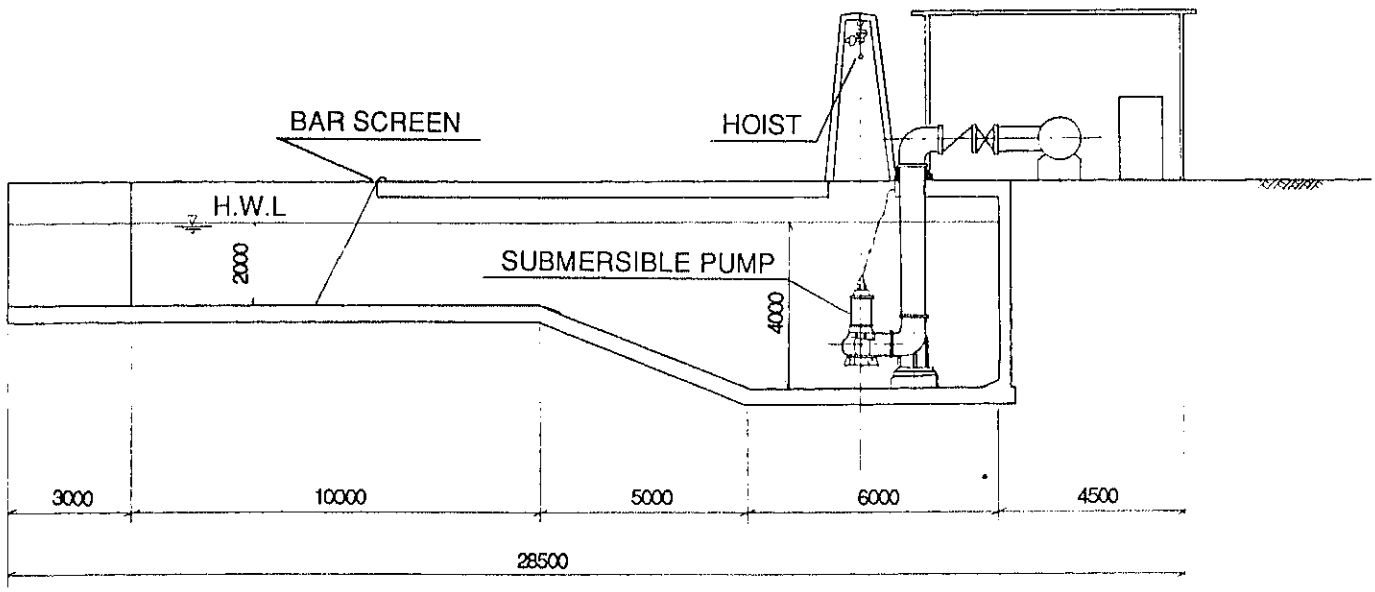


STORM WATER TRANSMISSION PIPE

FIGURE 10.8 TYPICAL CROSS SECTION OF OPEN CHANNEL AND STORMWATER TRANSMISSION PIPE

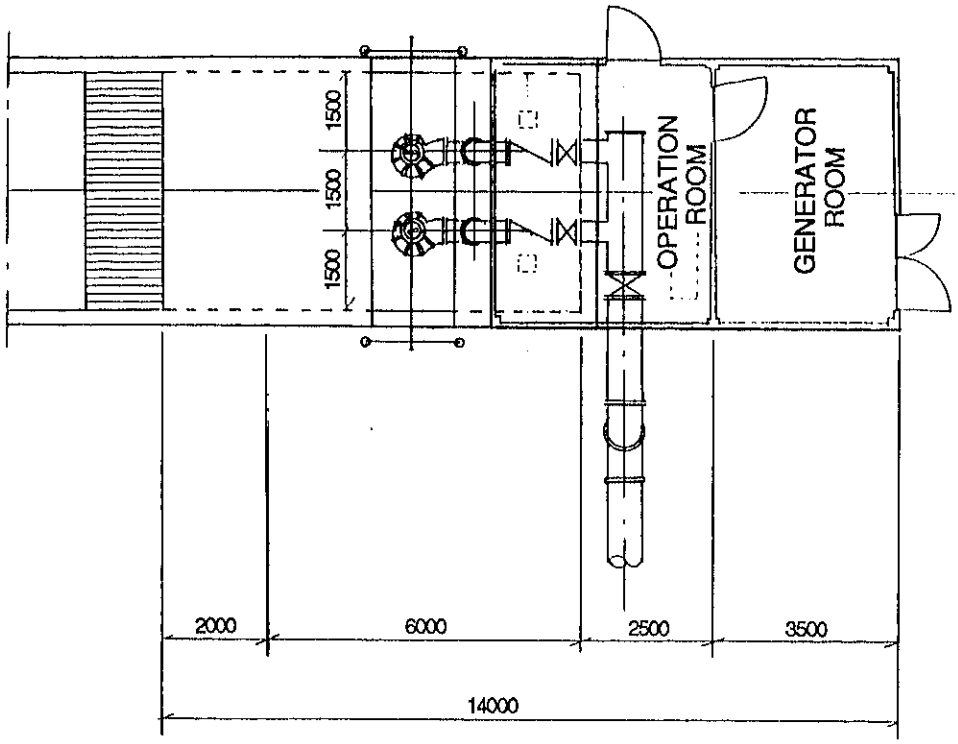


PLAN

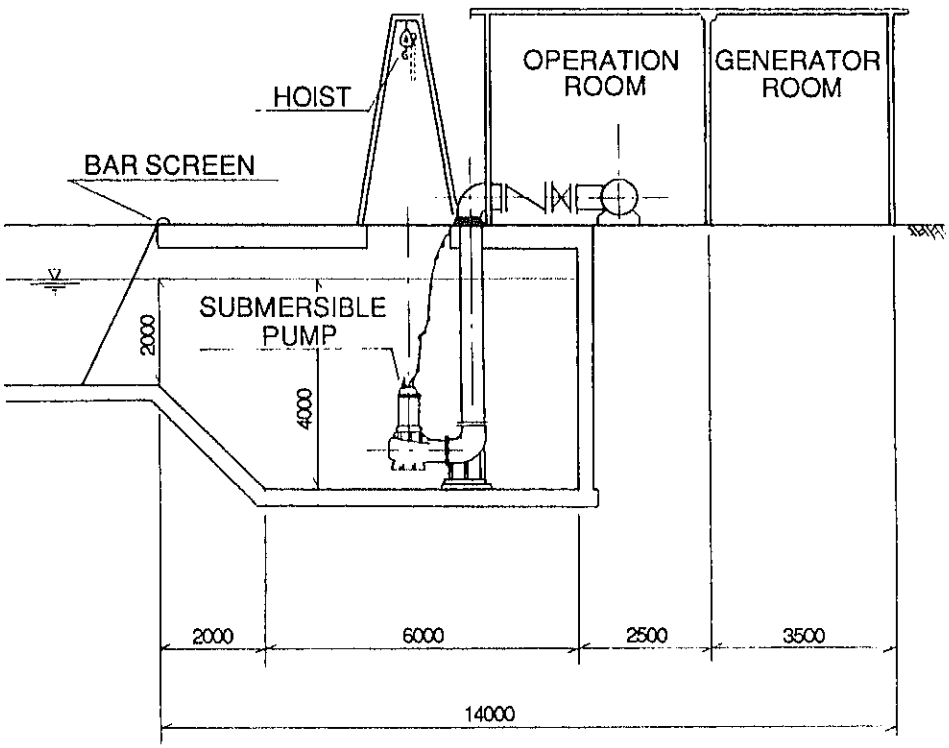


SECTION

FIGURE 10.9 TYPICAL DESIGN OF MAIN PUMPING STATION

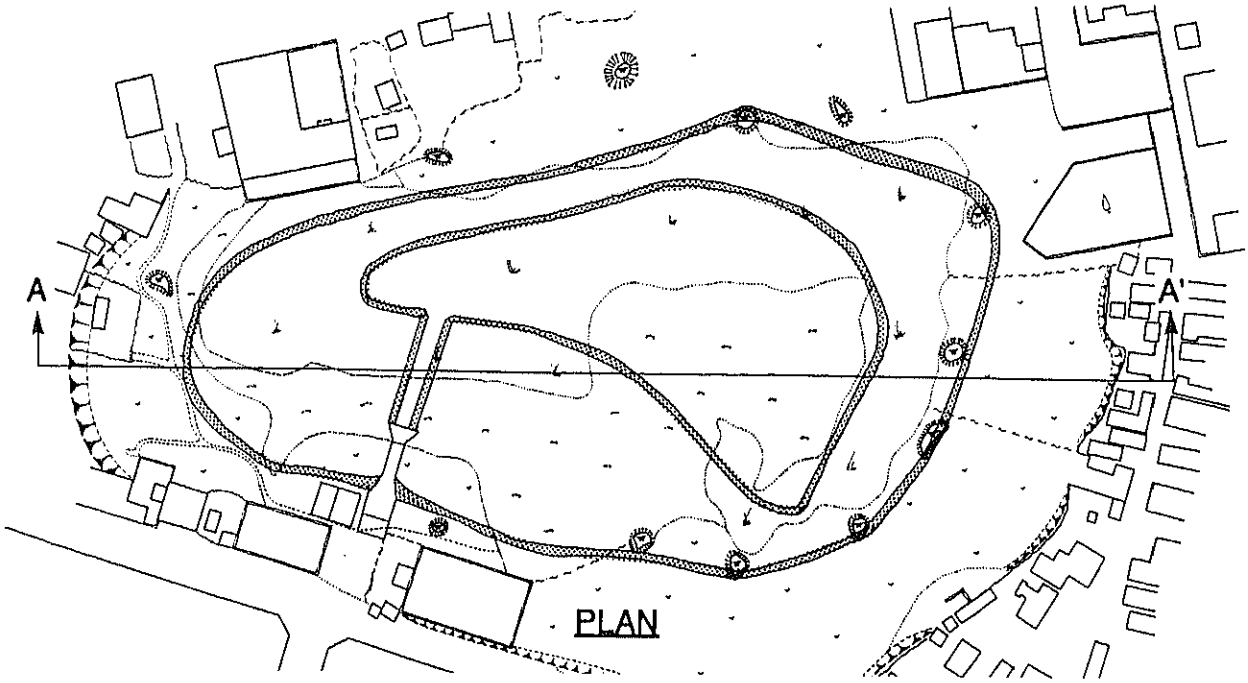


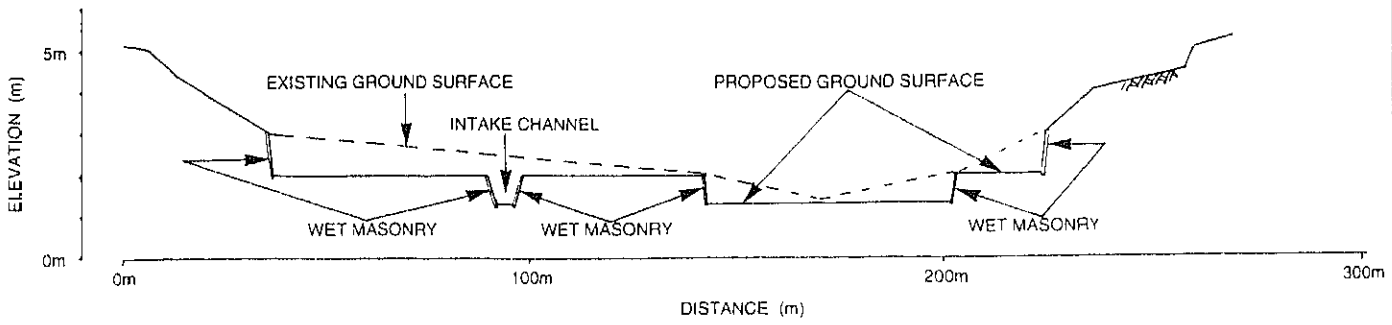
PLAN



SECTION

FIGURE 10.10 TYPICAL DESIGN OF SUB-PUMPING STATION





SECTION A - A'

FIGURE 10.11 TYPICAL DESIGN OF RETENTION POND

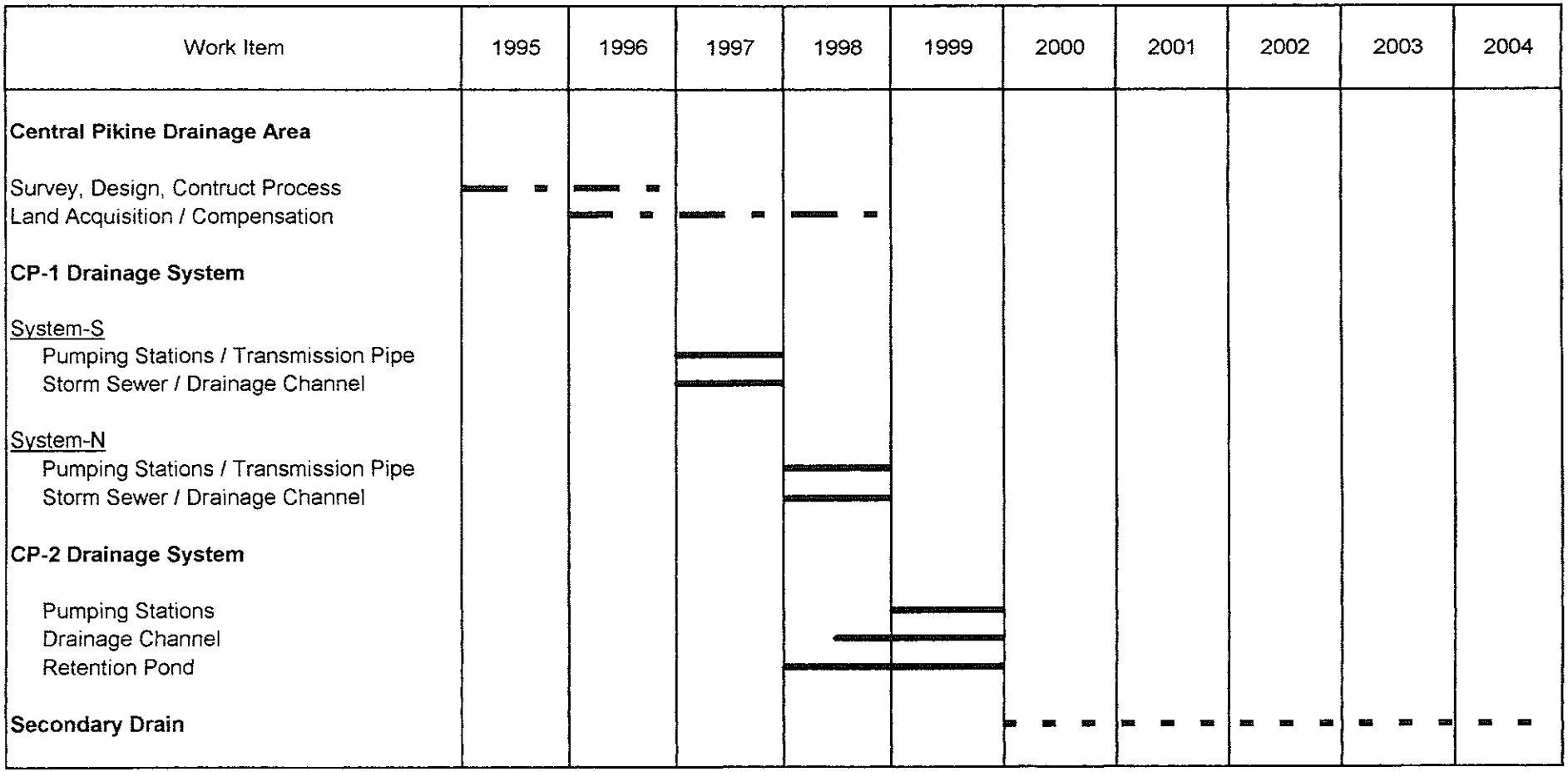


FIGURE 10.12 PROPOSED IMPLEMENTATION SCHEDULE OF PRIORITY PROJECT